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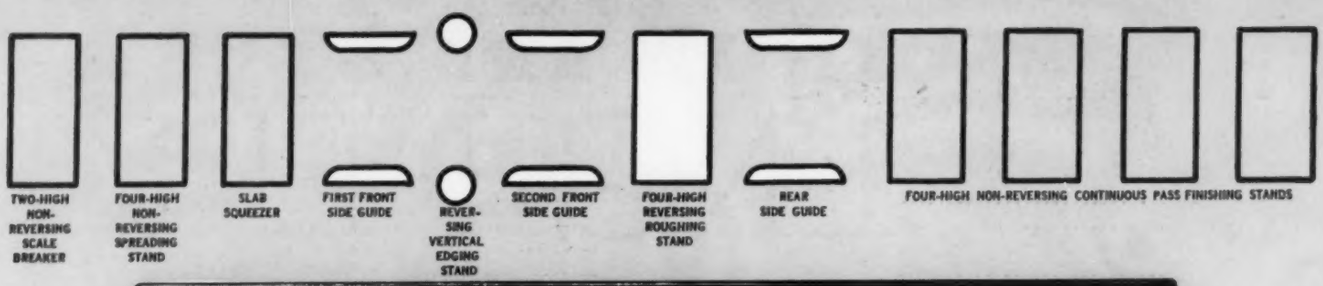

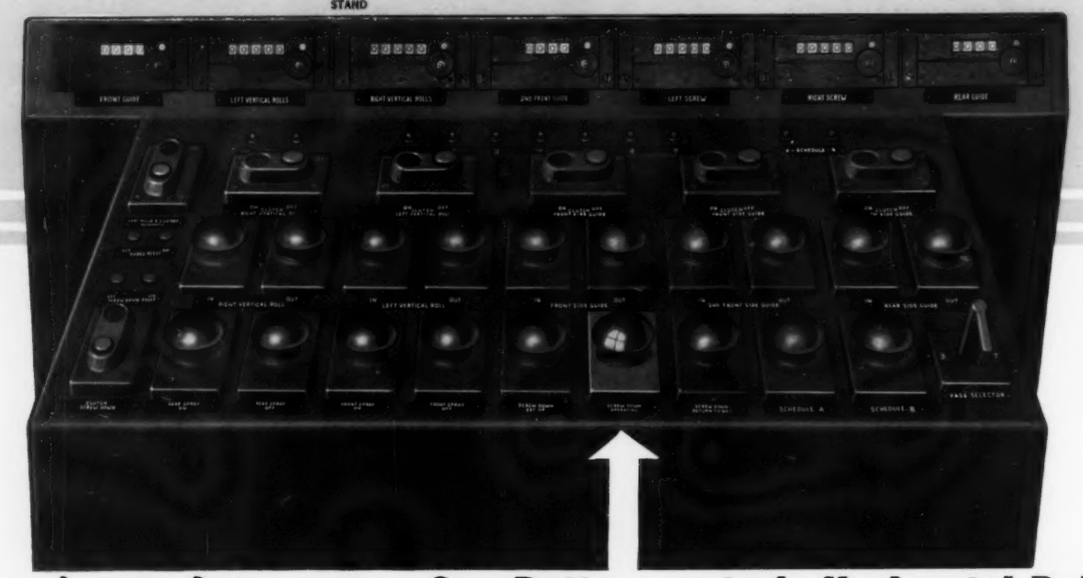

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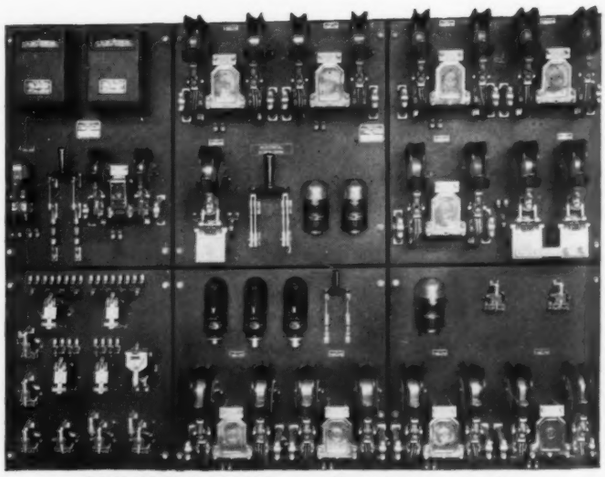

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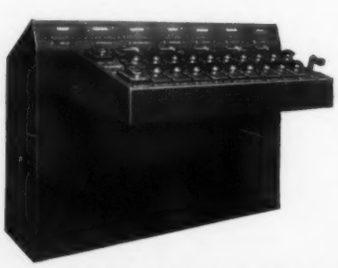
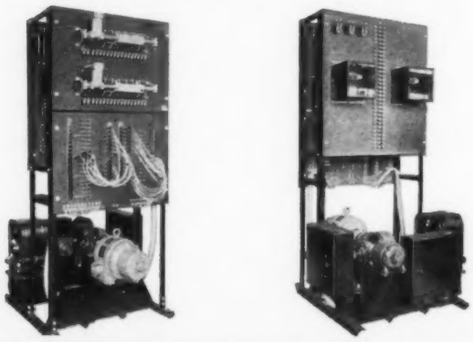


¾ view of operator's desk. On either side of this desk will be mounted a Manual Master Switch for hand operation of these auxiliary drives. In case of emergency, operation of these gives hand control instantly.



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Can Professional Labor Leaders Aid the Steel Worker?

INDUSTRY has just seen the termination of two lasting and costly strikes, one in glass, the other in the automotive industry, both fomented by professional labor organizers.

In both cases, the strikes resulted in extreme bitterness, in hardship for the families of the men, and in heavy financial loss to the companies. The damage went even beyond those immediately concerned. It was responsible for suspensions in production of a wide range of industries because of their interdependence on production of the great organizations involved.

The leaders of the committee for industrial organization undoubedly will attempt to capitalize the results claimed for labor. This raises the question: What were the results?

In both strikes, the workers obtained certain concessions from the management, but it is worth while to examine the facts and find out whether these concessions really were great enough to make the strikes a paying proposition. In the case of the glass strike, the men were idle for such a long period that they will have to work for over two years at the increased rates in order to make up for the wages lost during the period of the strike.

In the General Motors strike which lasted 42 days, the total cost to workers when the maximum number of plants were closed was $800,000 a day. The five cent an hour wage increase granted by General Motors was not part of the strike settled agreement, although the professional labor agitators will claim that the strike was influential in the granting of the pay boost. Here again an extremely long period must elapse before automobile workers can regain the actual cost of the strike to them.

This involves not only the actual money, but there is no way to estimate the damage through hardships suffered by families, in the loss of business to merchants, in the suspension of activities in related industries.

The situation in the glass and motors industries might be compared to that in the steel industry, which has had no breach with its employees. Under the employee representation plans of the various steel companies, a 10% wage increase was granted last November, and questions of working conditions have been settled in an amicable manner without recourse to any strikes with their accompanying loss of wages, interruption of production, and possible violence.

The handling of wage and working conditions in the steel industry has been carried on through this medium without the levying of any dues to men in the plants, although in some cases the employees have made voluntary contributions.

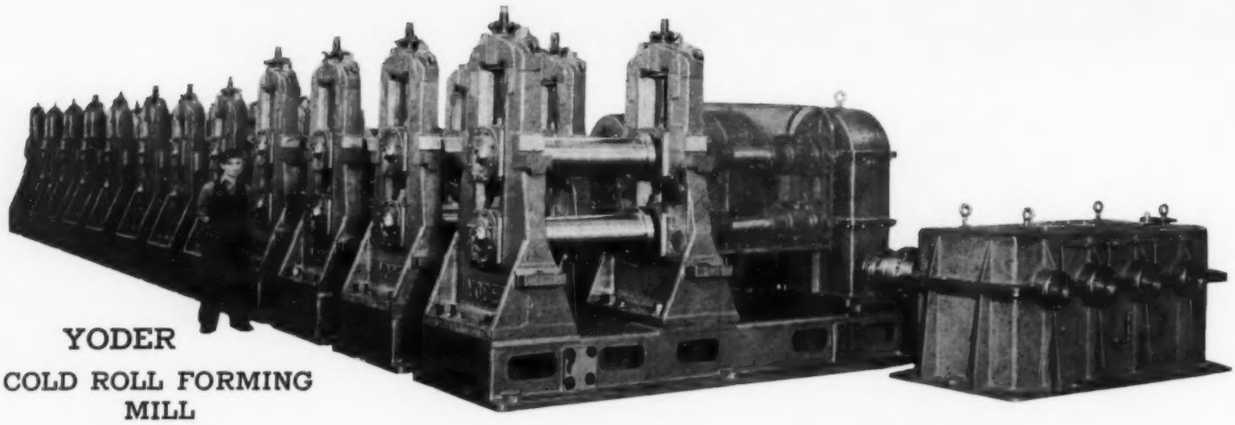
Comparison of these two methods of settling the differences which naturally develop between workers and management leaves little room for doubt as to which is the more desirable.

From the standpoint of the workers, the strike is a costly but not always necessary expedient which rarely pays in the long run.

The attempt of the committee for industrial organization to control labor and wages in American industries appears to be justified only from the standpoint of its leaders whose goal is power and the revenue to be derived from union dues.

The active membership of the Association of Iron and Steel Engineers, which showed its interest in the steel worker when it launched the National Safety Council in 1912, is convinced that the Employee Representation Plan as it functions today throughout the iron and steel industry is the most practical method of collective bargaining.

John Kelly, Jr.



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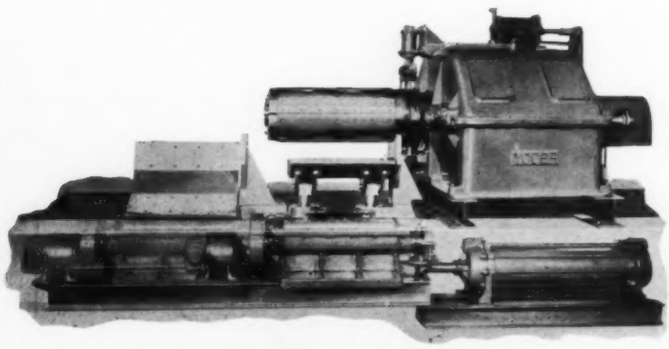

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Cold Roll Forming and Bending

By CARL M. YODER, President
The Yoder Company
CLEVELAND, OHIO

Presented before the Cleveland District Section A. I. & S. E., January 17, 1937.

▲ IT is not my intention to try to entertain you here tonight, but in a very informal way, bring out some of the high spots of the subject assigned, and also with your permission, make a few statements about the near future developments of the cold forming method as it will pertain to the Steel Industry.

I do not wish to come before you tonight posing as an expert or a prophet. I could not, no matter how much I would like to, because I am too near home. And "a Prophet is not without honor save in his own Country".

The subject of my discussion is,—"*Cold Roll Forming and Bending*", and while it is not entirely new, little is known of it by many engineers, especially among the steel mills. They only think of it as being used in very light material, such as mouldings for automobiles, metal windows, partitions and the like, so I have brought a few formed and bent pieces with me, some light and some of a little heavier metal, as there may be some here who have not seen some of the later developments of this sort, and it may also be necessary for me to back up some of my statements.

I do not expect that all of you will agree with me on all of my deductions here tonight for two reasons: First, I could not expect so many to agree with me, as there are times when I cannot even get Mrs. Yoder to agree with me on all of my deductions, and, secondly, because I have never seen a number of engineers agree on any one particular subject at the same time. That may be because they are either afraid of losing their rugged individualism, or that they are not just built that way.

The subject we have for discussion tonight is very timely, and to me, exceedingly interesting because of its rapid development and use.

We have been developing cold roll forming of metal for about thirty years, and the longer we are in it, the deeper the subject gets and the more widespread its applications, and the more we realize how little we know about it.

For many years, sheet metal was formed by the stamping process. As production demands increased and longer sections of mouldings were required than could be formed on the press or brake, the drawbench came into use. By this method, lengths up to thirty feet, and sometimes even to fifty or sixty feet, could be made.

This drawbench equipment consisted of a cluster of several pairs of idler rolls placed in housings at one end of a machine. This is followed by a long table somewhat longer than the length of moulding to be drawn, and equipped with a sprocket chain operating on sprocket wheels located at each end of this table; a gripper commonly called a dog is fastened to the sprocket chain and the power applied usually at the more remote sprocket wheel, which gives a direct pull on the dog and draws the metal through.

The starting of the end of the flat metal strip through the forming idler rolls usually proves to be quite a difficult task and consumes considerable time. Occasionally in recent years, the ends of the coils of metal were welded together, making a continuous strip, thus eliminating this threading operation.

When power was applied, the dog gripping the end of the metal, would draw the metal strip through the rolls, thus forming same into the required shape of cross section. When the end of the table was reached, the metal was cut off, usually with hand hack-saw, at a sufficient distance from the rolls for the dog to again grasp the strip. The dog was usually returned by hand. By this method, less than fifty per cent of time was used for actual production and a considerable amount of material was wasted in starting the ends of new coils of material through the forming rolls and also where the dog gripped the metal.

Again, as the demand for increased production became more acute, demand for higher speeds and less waste of material became imperative. This led to the development of the cold roll forming method. The equipment for cold roll forming consists of a plurality of pairs of power driven rolls, (the number depending upon the simplicity or complexity of the section to be formed) these power rolls propel the material through the machine, and at the same time form their portion of the section.

The better sets of forming rolls not only consist of the rolls, but also consist of guiding and holding means for the material, supporting it from one set of forming rolls to the next. Thus, shorter strips may be formed as well as material from coils of continuous lengths. However, it is more practical and less costly to form from the coil, and this we recommend whenever possible. Guiding means in our judgment, are necessary in most cases, as the metal must be held in control from the

time the flat stock enters the forming mill, until the completed section is delivered to the straightening and finishing end of the machine.

Exact lengths may be cut by an automatic flying cutoff machine which is placed immediately at the end of the forming mill. Thus the sections are formed and cut to the exact length required automatically and at a forming speed of from 40 to 300 feet per minute, according to the gauge of material and the contour of the section being formed. This is done without stopping or even slowing down the forming operation while the cutting off to length takes place, all with an accuracy of plus or minus $\frac{1}{64}$" for the average section.

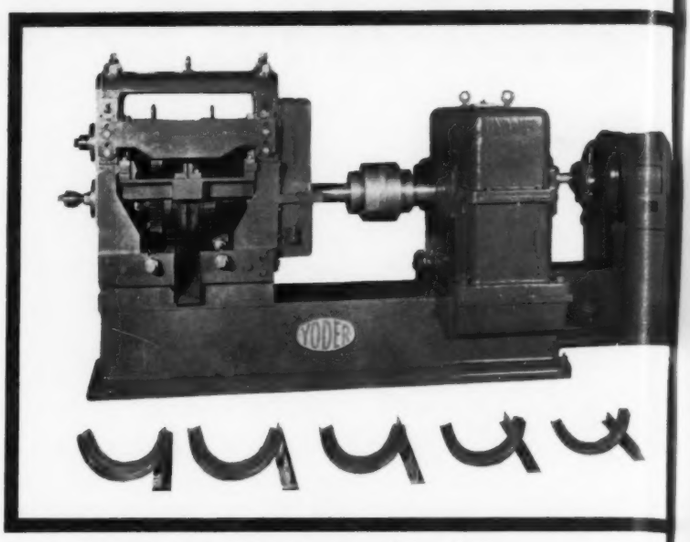
Where fine finish and accurately formed work are required, the steel to be formed must be carefully handled all the way from the billet. It is impossible to produce a fine, accurately finished article if the material is not accurately sheared and properly handled at the mill, and all the way up to the time it is formed. There is only one way to get a wrinkle or buckle out of sheet metal, and that is, not to allow it to get into the metal in the first place. After it is allowed to buckle or coil break, it is absolutely impossible to remove it without damage to the structure of the metal.

It is like this piece of paper: After wrinkling it, it can never be smoothed out as it was before. Neither can the metal, as a break distorts and tears the molecular structure, and no amount of re-rolling or working can put the molecules back where they were originally.

The manner in which the forming rolls are designed, has a great bearing, not only upon the finish and accuracy of the section, but also upon the physical properties and condition of the metal, such as strains, torsion, elongation, rupture of the molecular structure and many other conditions which will enter into the sections if they are not understood and eliminated in the roll design. In other words, a set of rolls may be designed so that when the material is formed, it will make a very weak and inferior section. If such a section is dropped or hit with a hammer, it will crack or break at some of the formed corners, especially if they are formed at a sharp angle.

Care must be taken in design, as to whether the metal is formed under tension or compression, and moreover, as to whether the strains are broken up and relieved or whether greater strains are rolled into the material. There are many important conditions to consider when designing rolls for cold working of metal. However, when this is done, a cold roll formed section will be from *ten to fifteen per cent stronger* than the same metal before it was cold formed, and the rolled section from 20 to 200% stronger than a hot rolled section of the same weight.

This is the reason why most of the hand books and formulas are of little assistance in figuring strengths of cold roll formed shapes. I have known of many cases where, under actual test, the cold roll formed section was as much as fifty per cent stronger than the engineers had figured it would be, and they were bewildered because of the results then found. Many new formulas and calculations will have to be worked out to provide data for use in designing shapes to be produced by cold rolling.



Front view of a brake shoe forming machine.

Another reason why the cold roll forming method is fast growing in popularity and use, is because of its greatly increased flexibility. For not only may shapes be formed in straight lengths, but also bent or circled simultaneously in the same forming operation. These formed, bent or coiled articles may be cut off automatically in circles or segments of circles. Illustrated are some of these rings for your inspection. These pieces are closing rings for metal containers with removable tops. They were formed, coiled and cut to the exact circumferencial length within $\frac{1}{32}$ of an inch—not in diameter, but circumference, and at the rate of 80 ft. per minute. It has been considered quite difficult to form a strip of steel into a mechanically true round tubing in straight lengths, and especially so, where the whole circumference of the tube was not formed, so that the edges could be butted together and thus the tube rounded and sized.

Shown is another section which was formed from the flat strip into cylindrical form, three quarters of the circumference, the center of the open seam being at a 45 degree angle from the top center line. As it left the forming mill, it was coiled into a $6\frac{3}{8}$ inch diameter coil, holding the opening in the exact position, and also maintaining truth as to roundness and the exact diameter and cross section, as well as the positive diameter of the coil, as you will notice this straight edge touches each coil.

Next we have an automobile radiator grille section. The soft steel body is taken from a coil, the edge formed, the stainless steel facing of about .006" thick, is also taken from a coil, and partly formed, and at about midway through the forming mill, it is brought into contact with the body strip which is being formed. The two pieces are then formed together as they pass through the remaining forming rolls, making a soft stainless faced steel strip which is then coiled as one piece, into circles and cut off either in a complete circle or into segments of a circle, automatically at any desired length at the rate of 80 ft. per minute.

These strips were similarly formed, except that both edges are formed simultaneously and two coils of stain-

less steel facing, are rolled, one over each edge, after it is completely formed in a straight length at a rate of 130 feet per minute.

This strip is slit through the center before leaving the forming machine, thus making a production of 260 feet of this stainless steel faced section per minute. As this formed section leaves the forming mill, it passes through the automatic cut-off which cuts the material to the exact length desired.

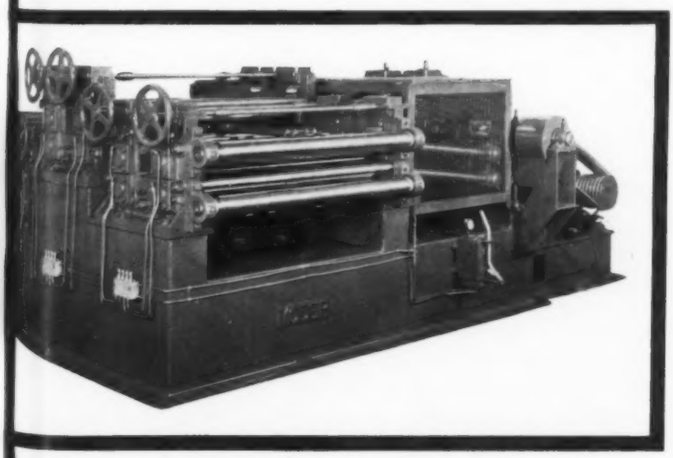
Making automobile radiator tubes is quite similar, although opposite methods are employed. The thin coils of copper, usually from .006 to .010 thick, are previously tinned. This tinned copper coil is placed on a reel in front of the forming machine, and there it is first cut to the exact length required while it is in the flat stock, at the rate of 250 ft. per minute, then automatically passed through the forming rolls, which form the radiator tube complete at the rate of 300 ft. per minute. Another method of making these tubes is to form them continuously from the coil, and after the tube is formed it passes through the solder bath, then is cut to length automatically.

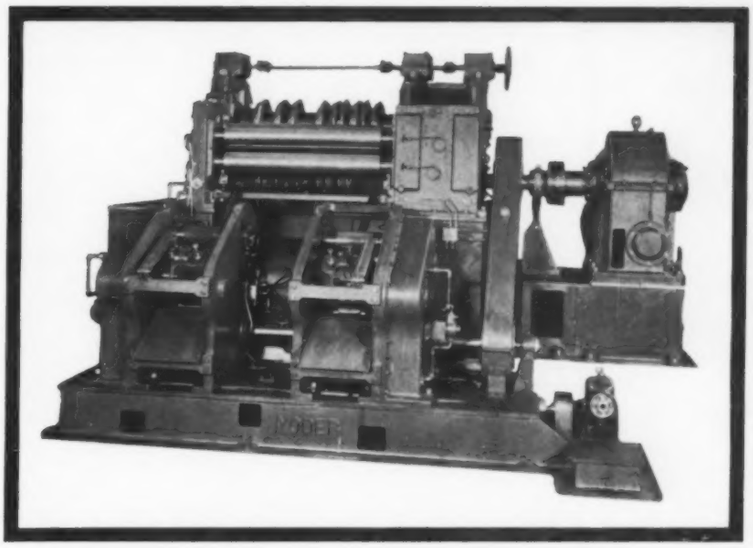
There are many instances where it is necessary to have mouldings so adapted that upholstering or other materials may be fastened to them with tacks or nails. In such cases a metal moulding is formed preferably around a fibrous or semi-flexible core, similar to the forming of the stainless steel facing, and the upholstering or trim is tacked to the core. In the event a core suitable for nailing is not practical or desirable, a shaped slot or crevice may be formed into the section, and when the nail is driven into this crevice, the metal not only holds the nail by friction against the sides, but also clinches the nail by means of a curved inner chamber.

Still another method is by spot welding two formed sections together at spaced intervals and the nails driven between these pieces. No doubt some of these methods or some very similar will be used quite extensively in the light weight building constriction such as residences and small buildings generally, since the various applications and variations are innumerable.

In many instances it is necessary to form the section in straight lengths, then bend the moulding to the required contour for use such as garnish and window

Multiple strip edge conditioning machine.





View of a side trimmer and slitting shear with scrap cutter.

moulding for automobiles. Here are some that have been bent. The cycle of bending requiring 6 and 8 seconds, thus permitting a production of from 3 to 5 per minute. After the forming, the ends are butt welded and flushed trimmed, thus making a complete window frame and garnish moulding.

There are countless variations in shapes of cross section and design that can be bent by this cold forming method.

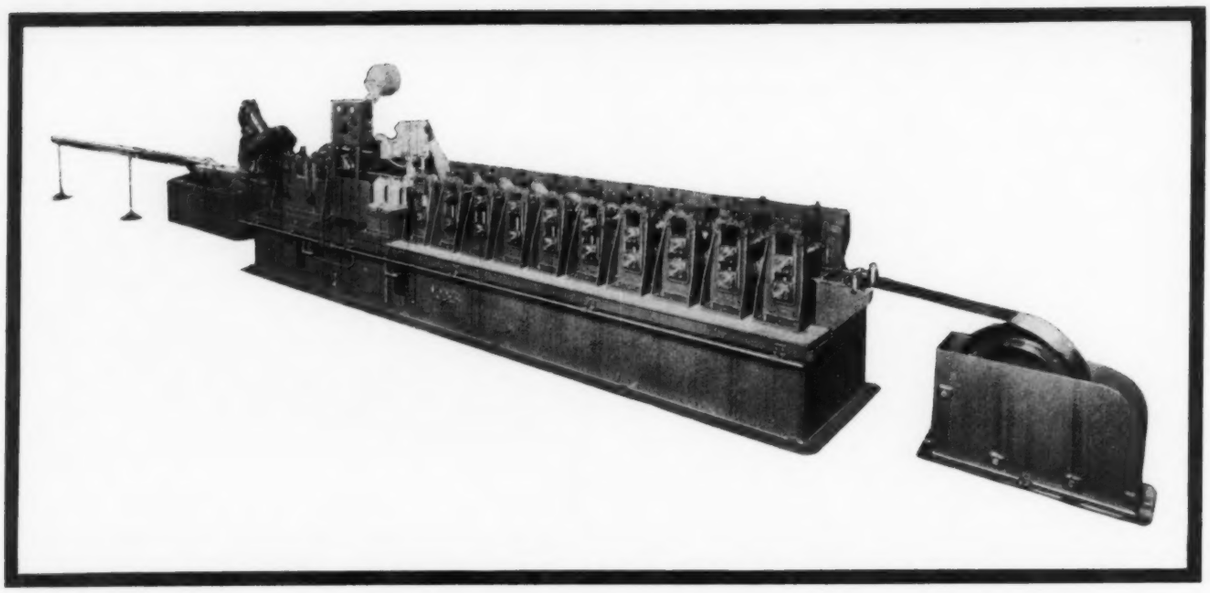
Brake shoes for automobiles and trucks are formed on this type of machine. They are formed or bent from hot rolled steel Ts of sizes ranging from 8″ diameter for the light pleasure cars of England, to 17 inch diameter by 4 inch face for the large trucks here in the United States. This size is being cold formed by one of the largest automobile companies at the production rate of 4000 per hour. These larger ones not quite so fast about 1600 per hour.

Standard pipe and tubing has always been produced by the butt and lap weld method. I venture to predict that there will be no new installation of these methods. At the present time a very sizable part of pipe tonnage is produced by cold forming and welding by gas or electricity. These methods are being used more every day until now tubing made in this manner is even invading the seamless tubing field to an amazing degree.

The electric welded pipe is cold roll formed in sizes ranging from $\frac{3}{8}$ inch O. D. to 26 inch O. D. in wall thickness from 20 gauge to $\frac{1}{2}$″.

Plates 83 inches wide, 50 feet long, and $\frac{1}{2}$″ thick, with 40 to 50 carbon steel, have been formed into pipe, at the rate of over 100 feet per minute in production, and could be formed 150 ft. to 200 ft. per minute, if the material could be handled that fast.

Small pipe such as conduit and mechanical tubing is formed as follows: The steel is taken from a coil which is placed in front of the forming mill. It is then formed into a tube, the seam welded, cooled, sized and straightened and automatically cut to exact required length in one continuous operation. This piece was so



Stock reel, forming machine, welder, sizing and straightening, and cutoff machine lineup.

made at the rate of 204 feet per minute. This speed was not a production speed because the material could not be handled that fast, but the average production speed is from 100 to 125 ft. per minute.

With your permission I am going to make a few statements as to the near future developments of the cold roll forming method. While many people are wondering what the steel mills are going to do with all of the continuous sheet mills, and have been saying it for the past several years, I will state in my opinion, there will be in the near future, more than twice as many continuous sheet mills in operation than there are at the present time, and they will all be running full time. My reasons for this statement are, that the coming of the light weight building construction alone will open up a field for steel tonnage many times larger than the present combined output of all of the steel mills, and this will be considerably augmented by the rapid development of the cold roll forming process in other lines, including cold roll formed structural shapes.

An engineering revolution has been gradually and quietly taking place in the structural field.

Most of the now low carbon hot rolled structural shapes such as angles, channels, Z Bars, I Beams and the like, will be cold roll formed from the flat strip. We also predict that in the near future, low carbon steel will be almost a lost art for general use in structural steel construction as alloyed steel of high tensile strength and of much greater resistance to corrosion will replace it.

I am told that approximately seventy-five percent of the cost of structural steel erected is in transportation and handling costs from the billet to the finished job, and also that over fifty percent of the total weight of a structural bridge is consumed in carrying the dead load of the bridge alone. By the use of alloyed steels, the same being one-third and more stronger than low carbon hot roll steels, and by changing the design of shape, all kinds of structures will be built from 40 to 50% lighter in weight, using light weight alloyed steel cold roll formed sections instead of low carbon hot rolled shapes.

These structural shapes will not be made in the old conventional shapes as are shown in the hand books, but will be of special design to best suit the position in which they are to be used, so as to give the greatest strength with the lightest weight possible. Therefore, the engineer will, to a greater degree, design the shapes to be used in the structure, as well as to figure the stresses and design of the structure.

Another important advantage in the cold roll forming process is that adjustable sets of rolls may be made so that shapes of various sizes and wall thicknesses may be formed on the same set of rolls. For instance, Z bars web sizes from $1\frac{3}{4}''$ to $12''$ and wall thicknesses from $\frac{3}{8}''$ to $\frac{1}{16}''$ or even greater, are formed on one set of adjustable rolls. Not only can the size and wall thickness be changed, but also a wide variation in steels may be formed on this same set of rolls, such as alloy steels, low carbon and high carbon steel, and the rolls will require only slight adjustment for straightening the various shapes as they leave the forming mill.

When these two pieces of Z bar sections were formed, the machine was adjusted for silicon chrome steel, and this piece of manganese steel was formed without adjustment of any kind. They are almost perfect. The variations in the forming qualities of the different steels are overcome in the design of the forming rolls, thus indicating that a wider variation of steels may be formed with their angles true to size and shape. Combination sets of rolls can be made for all sizes and wall thicknesses of angles and also for channels. In fact, adjustable rolls can be made for most of the standard structural shapes.

Many of the troublesome problems present in the production of hot rolled shapes, especially in the smaller sizes, are overcome in the cold roll forming of the shapes. There are no cobbles, no heating or annealing furnaces. No subsequent straightening operation is necessary, for, as the shape is cold formed the strains are broken up and relieved so completely that the section will not be distorted by handling and shipping, thus eliminating the tremendous amount of trouble and annoyance caused by distortion due to the pent up strains on these small hot rolled shapes.

I have mentioned only a few of the many advantages of the cold roll forming. In a development of this sort there are many angles to be considered; not only must the method of manufacture be carefully scrutinized, and the quality of the product carefully analyzed, but also the cost of manufacturing the product as well as the cost of machinery equipment and floor space required, all must be carefully considered, as they all have a great bearing on the practicability of the production method employed.

The cost of machinery, equipment, floor space and the cost of manufacture of the cold roll formed sections, will be very much less than the cost of the hot rolled sections.

The deeper one goes into the merits of cold roll forming with its innumerable variations and applications, and with its tremendous flexibility for changes to accommodate varying sizes and shapes, the more one appreciates the advantages of this method of production.

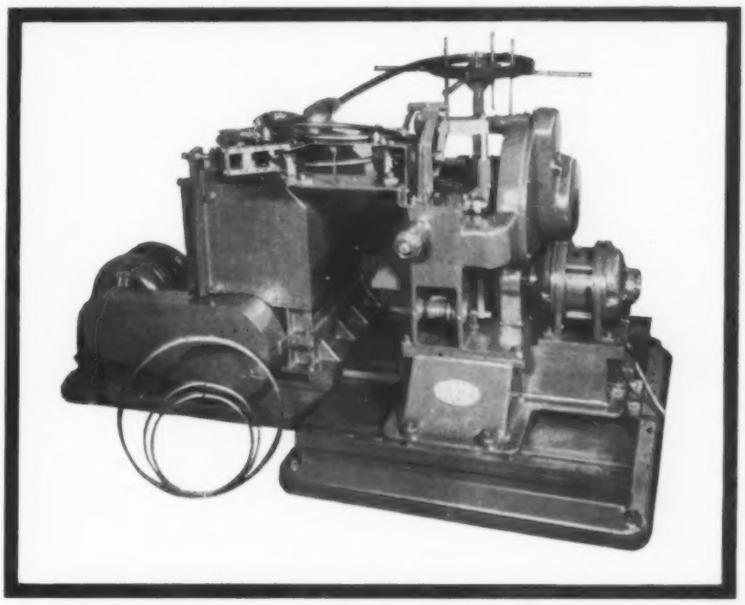
The forming of structural shapes as suggested here tonight, raises the very important question of accuracy and uniformity of the various sections when produced under regular production conditions, so that when the structural members are assembled, they will make a uniform structure. With properly designed forming rolls, stresses are relieved and the strains so broken up that the springback, which varies with the tensile strength and other qualities of the steel, is overcome and practically eliminated as is shown by these Z bars. This can only be accomplished by working the metal beyond its elastic limit, with the metal always held under perfect control. This is only accomplished today by the cold roll forming method. For example: In a right angle bend on a press or brake, with the same commercial steel, a wide variation from the 90 degree angle will be obtained.

When steel is being formed on the press or brake from material ranging from 10 to 40 or even 50 carbon content, or from the various alloy steels, this tensile variation is so great that a uniform product cannot be obtained.

Let us now consider the preparing of the steel previous to forming. As you know, in order to produce a quality product, the material must be carefully prepared and handled all the way from the furnace to the finished section.

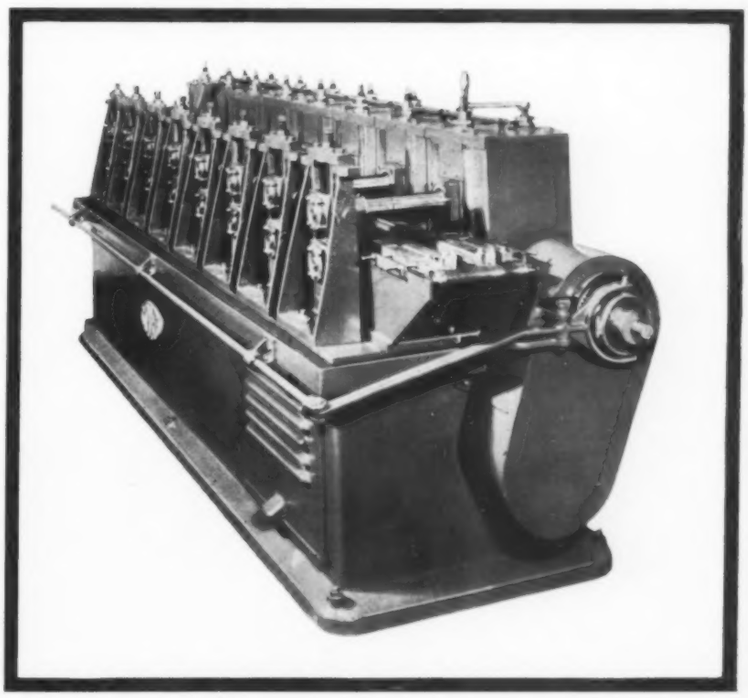
After the steel leaves the continuous sheet mill, it passes through many handling operations. There is the coiling and uncoiling, fastening together of the ends of the coils by various means, thus making a continuous strip for pickling and annealing. During these operations much damage is done to the steel by allowing it to pile up on itself in folds, or by drawing it from underneath a pile of great weight, thus causing undue strains and buckling and breaking of the structure of the steel. We understand this malhandling is in process of elimination at the present time.

The time is not far distant when the ends of the coils will be welded together so perfectly that the weld will



Forming, coiling and cutting off machine lineup.

View of roll forming machine showing drive and feed table.



be put through the rolls and rolled out, thus making a continuous strip of steel of indefinite length; thus offering to the consumer coils of stock of very large diameter, which is very much to be desired.

Another very important factor in the preparing of steel for fabricating is the shearing of the edges. Not only is this true in cold roll forming, but is equally true in stamping. In fact, in every method of operation where a great amount of deformation of the steel structure is required, much difficulty is being experienced in the severe working of steel, because of the slivery or pulled surface along sheared edges, which have the appearance of being checked or cracked or have a sharp broken edge surface. This condition of the edges produces the same effect on the steel strip as would a sharp corner in a shaft or other machine part, it will often crystalize or break at this sharp corner. It is therefore desirable to eliminate this pulled edge.

Today, shearing is more generally being done on rotary slitting shears. The slitter should be a very *accurately built machine tool* with ample adjustments for all wearing parts. The cutter shafts must be sufficiently large in diameter that practically no deflection takes place during the cutting operation. The mounting of the cutters on the cutter shafts should have a micrometer adjustment so that the relation between the cutter on the top shaft and the cutter on the bottom shaft can be perfectly aligned with the exact horizontal clearance between them for the thickness and kind of metal to be sheared. Slitting cutters should never be allowed to get dull or have rounded edges. They should be watched carefully and kept sharp and smooth and very accurately adjusted. To me, the slitting is one of the most important operations in the finishing department of the steel mill.

Sharp sheared edges may often be objectionable, as for instance, in the automatic feed mechanism for press operations or due to danger of cutting the hands in handling. This is particularly true of the light structural sections. Round edges or square edges with the sharp corners rounded and still retaining the width accuracy of the slit stock, would be very advantageous.

Any or all of these desirable characteristics are produced by edge conditioning equipment. A machine for this purpose can be used in several ways,—placing it in the shearing lineup, setting it up as a separate operation, or it can be made a part of the forming mill operation, as the sections are being formed. There is available a three tier edge conditioner suitable for a shearing lineup. In this, all of the strips are simultaneously edge conditioned as they are slit and recoiled. Much more could be said on edge conditioning, but time will not sanction it.

It is necessary before fabricating to kneed or further process the steel so as to equalize the molecular structure, relieving the stresses and strains so that an equal draw or uniform change in the steel structure will take place during the forming operation. This is more or less fundamental, and I believe we all agree up to this point.

However, it is rather generally believed that this processing operation must be made immediately before the forming operation—that is, within a few hours. With this theory I cannot agree, providing that the steel has been thoroughly, evenly and properly processed, for if the steel *has been* properly processed, all strains and stresses will be completely relieved, and therefore, cannot return. However, in my opinion, up to the present time, steel has not been uniformly kneeded throughout the entire length and breadth of the sheet, and therefore the internal stresses and strains are not completely relieved up to the ends of the sheet.

I am not in a position to go into too much detail concerning this. Our experiments have been mostly with strip and not with the wider sheets.

The various operations that I have briefly outlined, can be summed up in the following procedure of manufacture:

The ends of the wide coils of steel should be welded together before pickling and annealing, and this cross welded seam rolled out as a seamless strip into a continuous coil of very large dimensions. These coils continuing through the various finishing operations to the slitting lineup where this wide strip in coils will be uncoiled, and slit into any number of strips of the desired width, and in some cases, edge conditioned, processed and recoiled, or cut off to the required lengths, as the requirements may be, and this is true of either hot or cold rolled steel.

This material will be placed in front of the forming mill and formed into the required shape with smooth finished edges, all truly formed and straightened and automatically cut to the desired lengths, a complete commercial product, ready for shipment.

Centralized Lubrication
IN THE STEEL INDUSTRY

By E. J. EHRET
Chicago District Manager
THE FARVAL CORPORATION

Presented before the Chicago District Section, A. I. & S. E., December 1, 1936

▲ I CONSIDER it a real honor and a privilege to present a few practical facts on Centralized Lubrication in the Steel Industry. I want to present them to you along the same lines we would discuss the subject at your desk in your plant.

We all know that there is one thing that makes the wheels go 'round—and that is, first of all, orders; and then, proper lubrication of the bearings.

With hand methods and the human element involved, lubrication becomes a "hit or miss' proposition, resulting in either a feast or a famine. Centralized lubrication makes the job easy, and as a result it will be done. The job of greasing a lot of bearings is often put off to a time when there is nothing more important —when it's too late and the damage is done. Thus centralized lubrication has become an economic necessity. Good lubrication means the right lubricant in the right quantity and at the right frequency of application. Therefore a centralized system of lubrication to be correct should have the ability to handle any kind of a lubricant required by the bearing, and when you have control over the kind of lubricant, the quantity and the frequency, you get good lubrication.

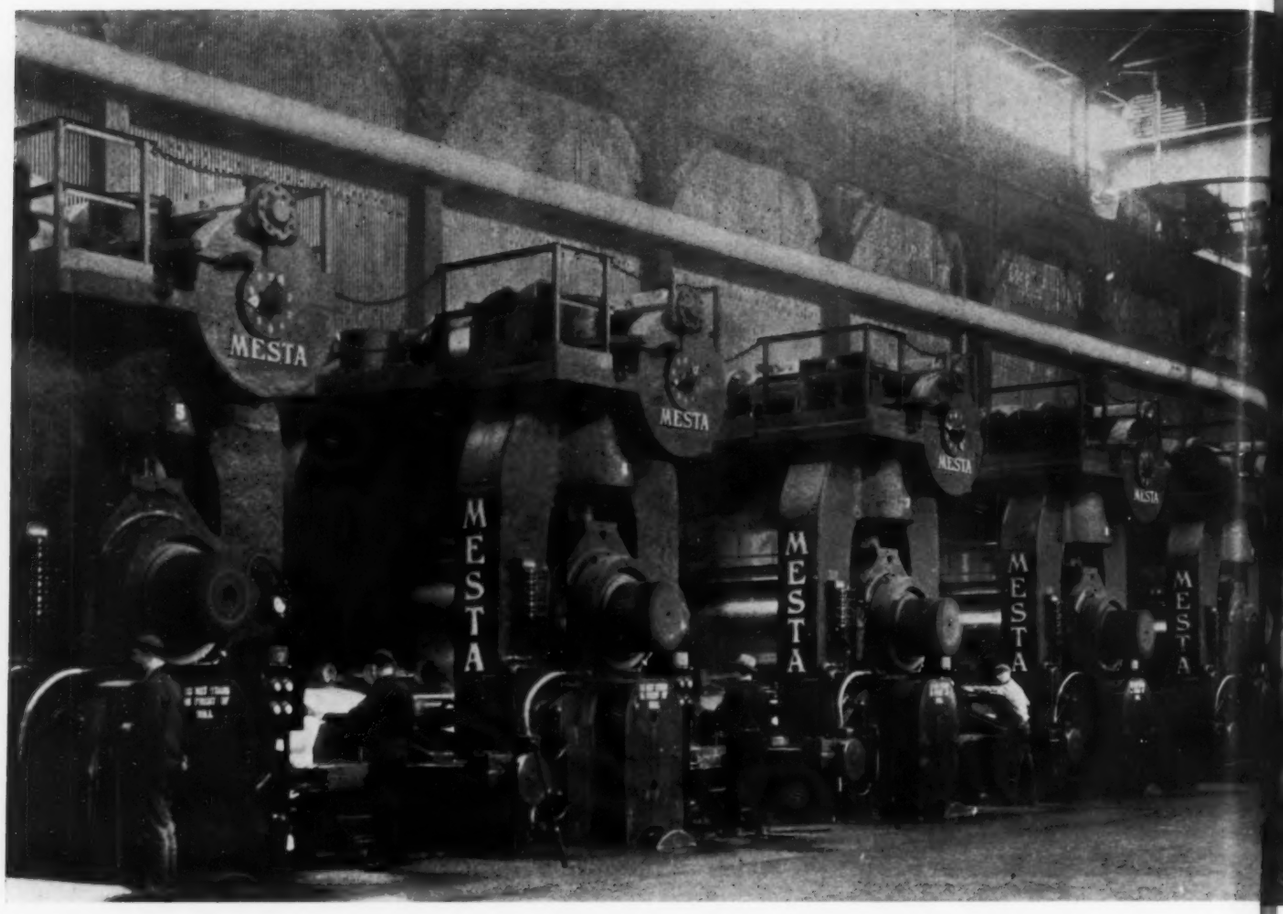
Eight or nine years ago, centralized lubrication was considered more or less in the light of a luxury and was applied to a few important pieces of new equipment or perhaps to only the toughest jobs in the mill. The experience and value of these early installations, however, proved the economy of centralized lubrication so that today, it is being applied to all kinds of production equipment.

THE SYSTEM

Most of the modern centralized systems of lubrication employ a piston displacement type of measuring valve to insure the unfailing delivery of a predetermined, measured quantity of lubricant to the bearing. The size of the valve chosen is determined by the bearing diameter, length, speed, load and general operating conditions, as well as by past experience on similar installations. These valves should be of simple rugged design and construction, to insure continuous trouble-free operation under all conditions of service. The use of generous ports and passages is desirable to give a wide latitude in the kind of lubricants to be distributed. All check valves should also be avoided from the hazard they present in the successful handling of mill greases. It is also very desirable to have an individual adjustment for each valve, in order to give the maximum flexibility for meeting a wide variety of bearing sizes and operating conditions. Another refinement which has been incorporated in many of these valves is the individual indicator which permits a check on the positive delivery of grease to any bearing at any time. It is also usually preferable to mount the grease measuring valve as close to the bearing as practical, in order to reduce and simplify the piping arrangement.

THE PUMP

Positive and dependable performance of the Central Pumping Unit is essential to the successful and continued operation of any centralized system. The reciprocating plunger pump has generally been found to be the most satisfactory type for this service. Spring pressed ball and check valves present a serious hazard in the handling of mill greases, and should be avoided wherever possible in the pump design. Consideration should also be given to the matter of service and replacement parts because any pumping unit, regardless of design, will eventually wear and need to be serviced. The design of central pumping unit, therefore, should permit of quick and easy replacement of the wearing parts in the field, with the minimum amount of time,



Automatic Time Clock Controlled System of Centralized Lubrication on Hot Strip Mill Finishing Stands.

and for a reasonable cost. It is also desirable to provide reservoirs having follower plates, in order to insure proper priming of the pumping units, when using heavy lubricants and provision should further be made for filling these reservoirs without contaminating the lubricant. A barrel transfer pump or a portable pack, with a suitable quick connection, is generally found satisfactory.

THE PIPING

The piping should be of proper inside diameter to reduce the line friction and provide high pressure delivery of lubricant, sufficient to overcome the resistance of the most remote bearing in the system, having in mind viscosity of lubricant in the winter—also the viscosity of heavy high temperature lubricants such as used on furnace tables, mill tables, hot metal cranes, etc. It is very desirable to have full main line pressure available at each valve. Where supply lines are exposed to cold, auxiliary heating or steam tracer lines should be installed.

Galvanized or seamless steel piping should be used on most steel mill installations to withstand rough usage. Exceptions are the levellers, shears and other thoroughly protected equipment where in a few cases copper tubing may be used and in others soft steel tubing.

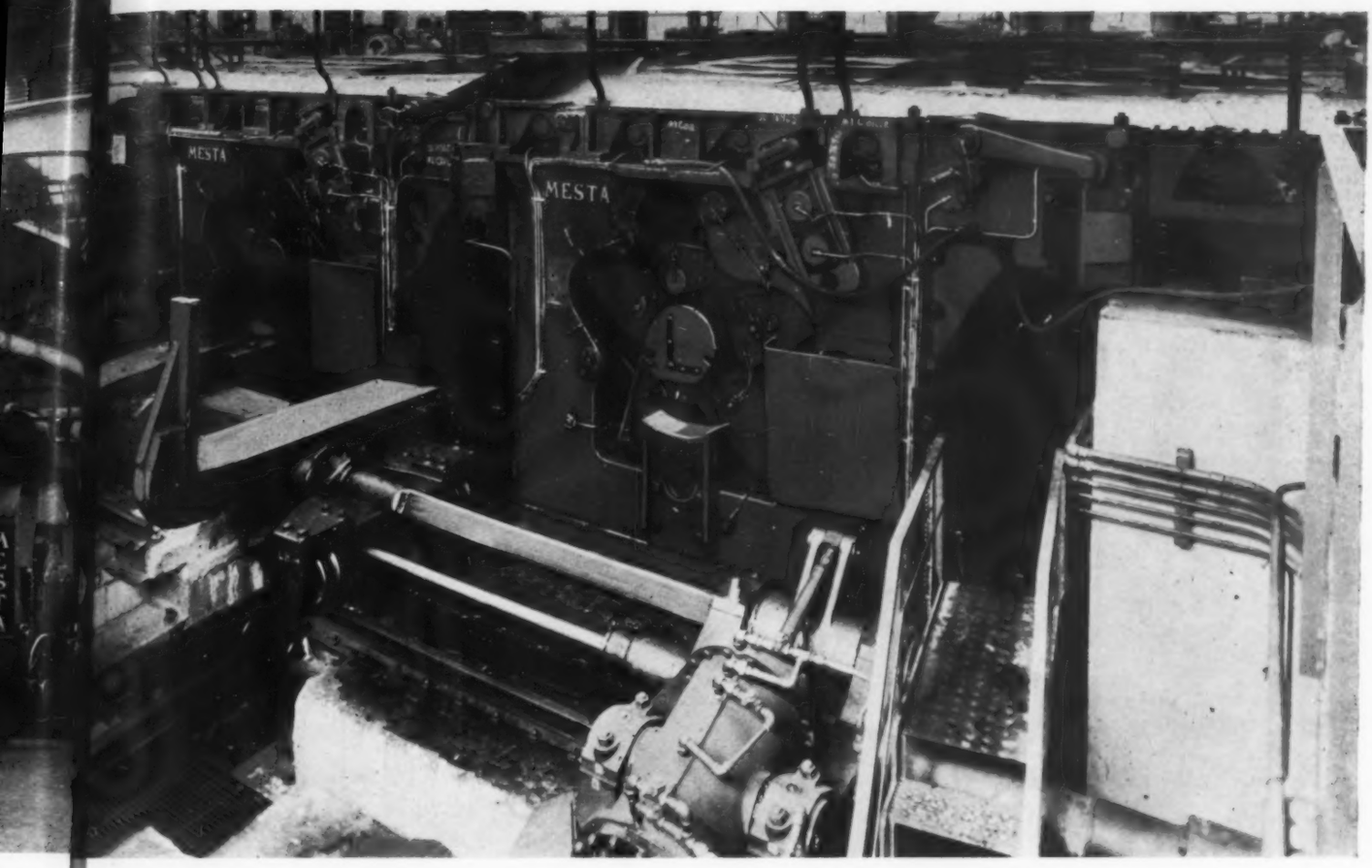
INSTALLATION

In most cases the installation of centralized systems are made under the supervision of experienced mechanics furnished by the vendor, plus labor furnished by the mill. This is by far the most practical and economical way of doing the job. There are short turns to every trade and by the above method the mill pays for only as much time as is furnished. Usually the vendor of centralized lubricating equipment furnishes the pumps, valves, hose, hose fittings, quick unions, strainers, gauges, etc., while the mill furnishes all of the pipe and fittings required for the installation.

TYPES OF INSTALLATION AND EXPERIENCE

1. *Ore and Coal Bridge Trolleys:*

A man was recently killed in this district lubricating



Centralized Lubrication on Hot Strip Mill Coilers.

coal bridge trolley at a cost many times the cost of a lubricating system.

2. *Coke Plant Pushers.*
   Door Opening and Closing Machines
   Chargers
   Conveyors
   Mixers
   Shakers and
   Cranes.
3. *Blast Furnace Tops.*
   Roll Feeders
   Screening Stations.

In the case of Blast Furnace Tops, the original installations were made with the thought of safety for the operator, due to his exposure to the gases on top while greasing or making inspection. Experience with centralized lubrication has definitely shown that due to proper and frequent application of lubricant, bearings and parts wore so much longer that the maintenance and repair economy became an important result of the installation and paid for the system quickly.

On a Blast Furnace top installation, the pump may be located in the hoist room, 200 ft. below the top and all bearings on top can easily be lubricated several times a day. Installations of this type went through the severe cold of last year over the lake, where probably 20 to 25 degrees below zero was experienced. Of course, the grease used had a low pour test oil, insuring mobility at those temperatures.

4. *Open Hearth.*
   Ladle Cranes
   Mixer Drives Cranes
   Furnace Reversing Valves
   Charging Cranes and Machines
   Convertor Vessel Trunion Bearings.

All have had successful installations. Where these bearings are exposed to heat, the higher melting point lubricants are used with excellent success in combination with the system. Again a tough job is made easy and therefore it is accomplished.

5. *Blooming Mill, Slabbing Mill and Plate Mill.*
   Manipulators
   Slab Pushers
   Pit Cranes
   Soaking Pit Cover Lifters.

Blooming and Slabbing Mills are being equipped and

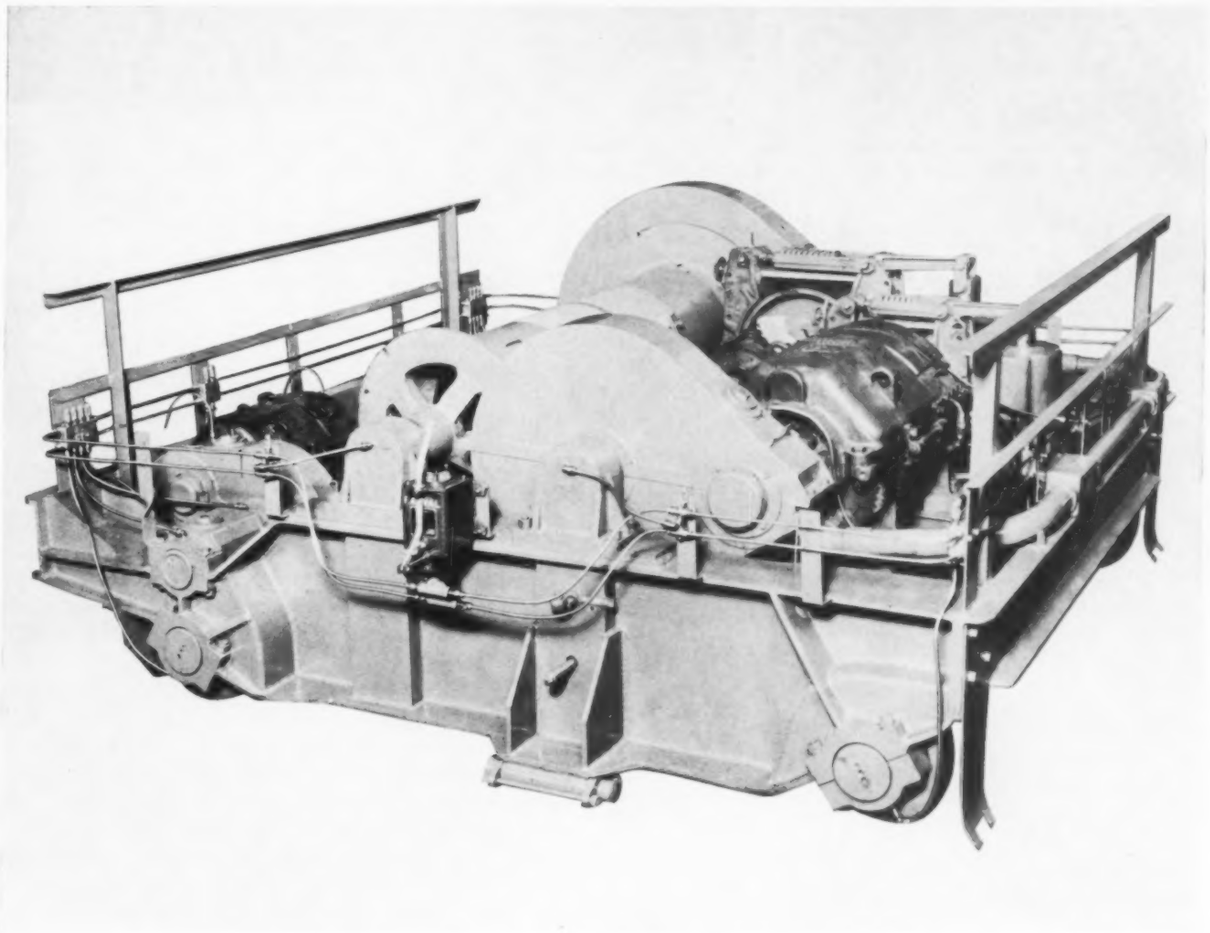
were among the first installations. Neck bearings are properly prepared with grooves, both for the radial and the thrust areas and with a sufficient quantity of lubricant delivered at frequent intervals, bearing life has been increased as much as 85%. This, of course, is accomplished by reducing the friction and by the same token up to 10% power is saved. The additional life of the bearing, power and lubricant saved, etc., pays for the system several times in a year. In cases where Blooming Mill tables and manipulators have plain sleeve bearings, they can also be advantageously tied into the same system as on the mill. Where roller bearings are encountered on the tables, they naturally require a different lubricant and should have a separate system. One great advantage of a centralized system on roller bearing tables is the delivery of clean lubricant and a small quantity frequently rather than the bearings being filled up and the lubricant being put under pressure in the bearings.

Hot Bloom and Billet Shears should have an automatic centralized system of lubrication. For this service it has been found that heavy-bodied steam cylinder oils give very satisfactory results.

6. *Billet and Skelp Mills, Structural and Rail Mills, Sheet Mills and Pipe Mills* and all of their miscellaneous equipment have had centralized lubrication applied with outstanding success and economy.
7. *Continuous Hot Strip Mill.*

95% of Hot Strip Mills are equipped with centralized

Centralized Lubrication on New Blooming Mill Roll Necks, Manipulators and Tables.



Manually operated system of Centralized Lubrication on Crane Trolley.

lubrication. Most of them have anti-friction bearings throughout, although some have Babbitt Bearings on the Roughing Stands. A centralized system insures regular delivery of a small quantity of clean, fresh lubricant to all bearings. Most anti-friction bearings on these mills are equipped with thermo-couples to indicate the temperature in the bearing, and as the temperature rises, the lubricant supply is increased either through the medium of the adjustable lubricating valve or by increasing the frequency.

The furnace delivery and entry tables on Hot Strip Mills are extremely important units. Should the rollers on No. 1 Furnace stick due to carbonization of the lubricant or lack of lubrication, no steel can be delivered from No. 1 Furnace to the Mill. If No. 2 Furnace table sticks, steel is only available from No. 1 Furnace, etc.

Delays of two to three hours a week have been encountered on these Strip Mills due to furnace delivery tables sticking. Some of these delays ran up to $400.00 per hour or around $1,000.00 a week. In three months' time, with a system installed, there hasn't been one minute's delay. On this basis, approximately $50,000.00 a year is being saved on a $4,500 investment. Most such tables are being equipped or are now equipped with a centralized system of lubrication which eliminates this costly delay by providing unfailing application of lubricant, and has paid for itself in some mills in thirty days. Combination of a small quantity of high melting point grease frequently applied prevents carbonization.

Furnace pushers can be left to hand operated centralized systems. Coilers and reels are an important unit on the other end of the mill and require centralized lubrication, because with the water and all, it is next to impossible to lubricate by hand. These systems should be motor operated.

Lack of lubrication causes the coils to stick, holds up the mill, shutting down an investment of several million dollars.

We've seen coiler bearings with centralized lubrication at the end of over two years' service that were in perfect condition—all of which translated into dollars means a saving *with* centralized lubrication, and a very definite loss *without*.

Cooling beds and drives, taking in 700 or 800 bearings lend themselves to either manual or automatic centralized lubrication and in either case make it possible to lubricate these many bearings from above in a matter of minutes, whereas they are overlooked when it is necessary to do the job from the pit.

8. Over 6,000 bearings on one coil conveyor, taking coils from coiler to storage and pickling lines are included in a recent Strip Mill installation. Imagine getting these by hand.
9. *Pickling Lines.*
   Uncoilers
   Stitchers
   Sheet Processors
   Recoilers.

A hand system for the bearings on the entry machines and another hand system for the machines on the recoiling end of the line, provides a very practical installation.

10. *Cold Strip Mills, Four Hi Cold Reduction Mills* (in single stand and 3 and 5 stand Tandem), *Steckel Mills, Skin Pass Mills.*
    Saddle Bearings
    Levellers
    Coilers
    Reels
    Shears
    Pinch Rolls
    Cranes
    Slitters.

In connection with the Skin Pass Mills, the system should be timed to deliver the exact quantity of lubricant the bearings require to prevent excess lubricant getting onto the product.

In connection with centralized lubrication on cranes in Hot Strip, Cold Strip, Tin Plate Mills, Merchant Mills, etc., the System performs an invaluable service by eliminating the spillage getting onto the product from the hand method of lubrication. The amount of the lubricant delivered to each bearing is controlled by adjustable valves, insuring proper lubrication to all bearings, with safety.

In the case of anti-friction bearing equipped cranes, the system insures delivery of clean lubricant and the right quantity. We have found cases where a group of roller bearing cranes were equipped with centralized lubrication and no bearing difficulties were encountered, while another group of cranes where the system was left off, considerable trouble was experienced. This is no reflection on the manufacturer of roller bearings, but indicates that lubrication is usually overlooked because it's too big a job to accomplish in the time available. Another noticeable improvement is that cranes equipped with centralized lubrication are usually very clean, because they are easy to keep clean. The system also prevents over-lubrication of Roller Bearings.

ECONOMIES

When properly installed, the system will quickly pay for itself by providing proper and unfailing delivery of lubricant to every bearing.

By providing a handy means of application, the job of lubricating a number of bearings through the medium of a centralized system is accomplished in seconds, and is done as frequently as is necessary instead of at widely separated intervals, like weekends or at the end of a turn.

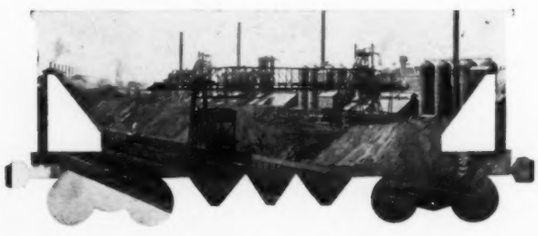
This definitely prolongs the production life of the equipment, eliminates costly shut-down periods and lost production, as well as expensive repair material and labor charges, which reflect themselves in higher departmental costs per ton.

A centralized system of lubrication provides a *safe, clean* and *quick* way of doing an important job, often left to the most lowly of a maintenance crew.

A centralized system eliminates waste of lubricant and so makes it possible to pay for the best lubricant for the job.

All of these items indicate that centralized lubrication will pay for itself at least once a year and in many cases a dozen times.

When you purchase Centralized Lubrication, you are actually buying an insurance policy to protect the dollars you have invested in expensive production equipment and to insure its ability to produce and earn a dividend on this investment.



ASSOCIATION OF IRON & STEEL ENGINEERS

NATIONAL MEETING

YOUNGSTOWN, OHIO

FEBRUARY 25, 1937

The technical sessions of this national meeting of our Society will be held in the Ball Room of the Ohio Hotel, Thursday morning. In the afternoon an inspection trip will be made to the Campbell Works of the Youngstown Sheet & Tube Co. Complete details of the meeting and inspection trip will be found in the following pages.

ASSOCIATION OF IRON & STEEL ENGINEERS

PRESIDING OFFICERS AND SPEAKERS

Chairman
C. J. DUBY,
Chief Engineer,
Republic Steel Corporation,
Warren, Ohio.

Secretary
C. H. WILLIAMS,
Assistant Chief Engineer
Carnegie-Illinois Steel Corporation,
Youngstown, Ohio.

Author
W. B. SNYDER,
Industrial Engineering Department,
General Electric Company,
Schenectady, N. Y.

Author
M. H. MAWHINNEY,
Consulting Engineer,
Salem, Ohio.

OFFICIAL PROGRAM

BALL ROOM OHIO HOTEL

YOUNGSTOWN OHIO, FEBRUARY, 25, 1937

Papers to be presented

9:30 A.M.

"Industrial Furnace Design" by M. H. Mawhinney, Salem, Ohio.

10:30 A.M.

"Ward-Leonard Control for Blooming Mill Auxiliary Drives" by W. B. Snyder, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

11:15 A.M.

"Continuous Rolling of Hot Strip Steel" by A. F. Giese, Jr., Gary, Indiana.

These meetings will start promptly and we would like to ask our members and guests to be on time so that the program can be carried out as planned.

INSPECTION TRIP

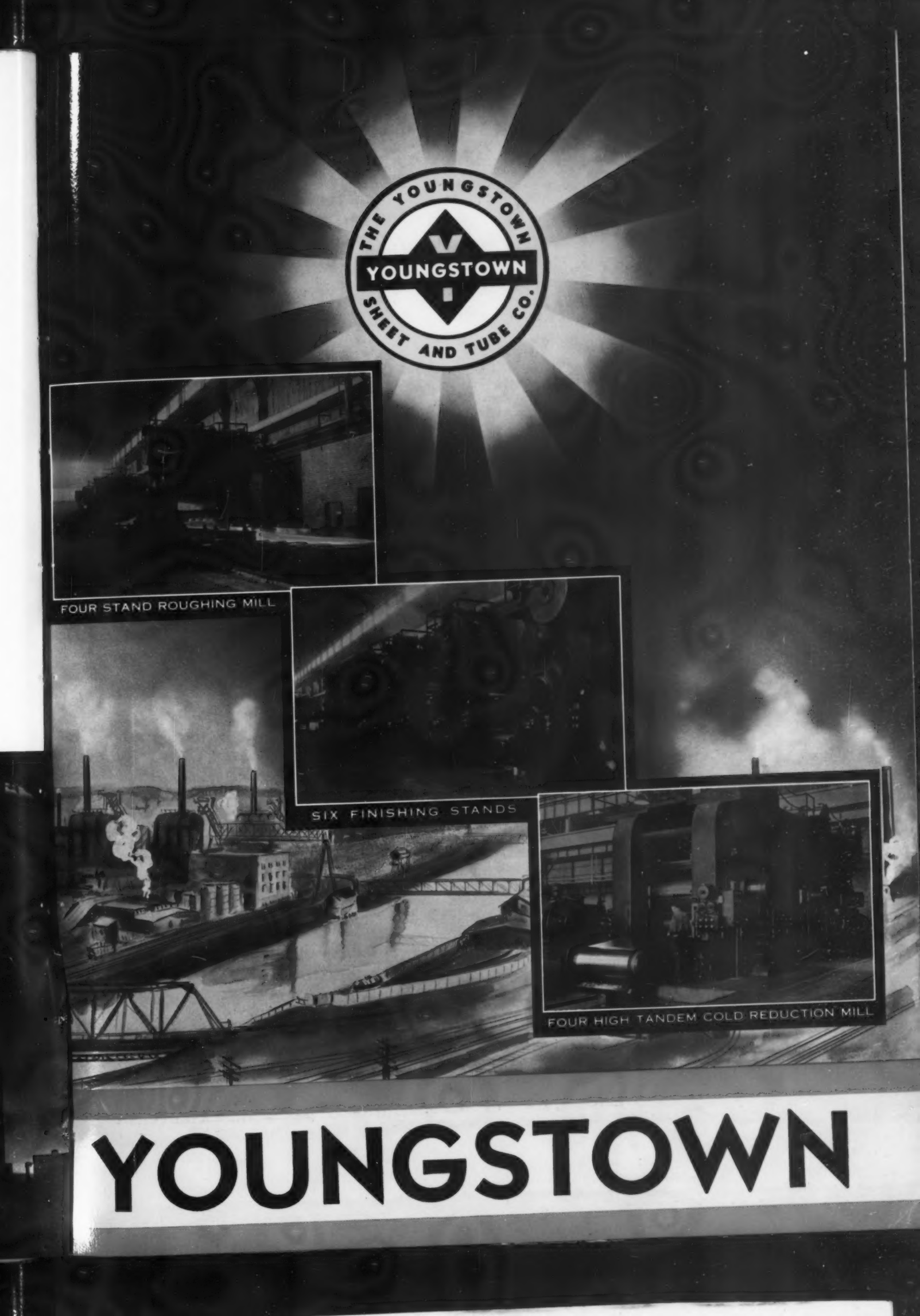
YOUNGSTOWN SHEET & TUBE COMPANY

CAMPBELL WORKS

1:15 P. M.

The buses for transporting our members and guests to the plant will be at the side entrance of the Ohio Hotel at 1:00 P.M. and will leave promptly at 1:15 P.M. Tickets for this trip may be secured at the Registration Desk of the A. I. & S. E. located on the Ball Room Floor of the Ohio Hotel. The price will be $1.00 per person.

Youngstown Sheet & Tube Company's 79″ hot strip mill.


THE YOUNGSTOWN
YOUNGSTOWN
SHEET AND TUBE CO.
FOUR STAND ROUGHING MILL
SIX FINISHING STANDS
FOUR HIGH TANDEM COLD REDUCTION MILL
YOUNGSTOWN

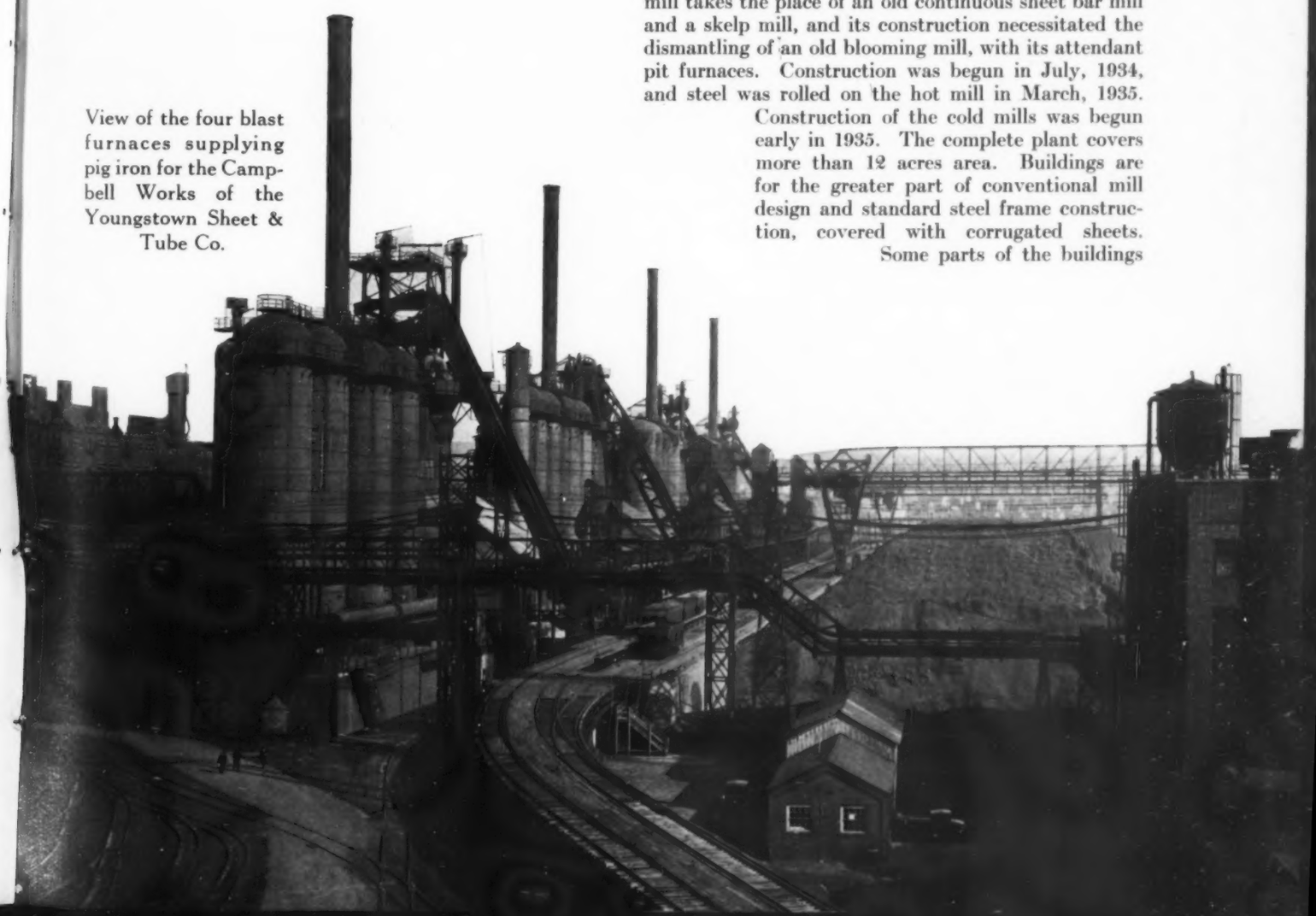
Frank Purnell
President
Youngstown Sheet and
Tube Company

YOUNGSTOWN

STRIP MILLS

CONTINUOUS HOT AND COLD STRIP MILLS AT CAMPBELL WORKS, YOUNGSTOWN, OHIO

▲ THE continuous strip mill at the Campbell plant of the Youngstown Sheet & Tube Company has a nominal capacity of 600,000 tons per year. The new mill takes the place of an old continuous sheet bar mill and a skelp mill, and its construction necessitated the dismantling of an old blooming mill, with its attendant pit furnaces. Construction was begun in July, 1934, and steel was rolled on the hot mill in March, 1935. Construction of the cold mills was begun early in 1935. The complete plant covers more than 12 acres area. Buildings are for the greater part of conventional mill design and standard steel frame construction, covered with corrugated sheets. Some parts of the buildings



View of the four blast furnaces supplying pig iron for the Campbell Works of the Youngstown Sheet & Tube Co.

Pouring of steel at night is always a striking scene and this above illustration shows the practice at the Campbell Works.

were formed by the alteration of existing buildings. The new mill is designed to produce light plates and skelp ½″ to ¼″ in thickness, hot rolled sheets up to 72″ in width and down to No. 18 gauge, with a minimum width of about 18 inches.

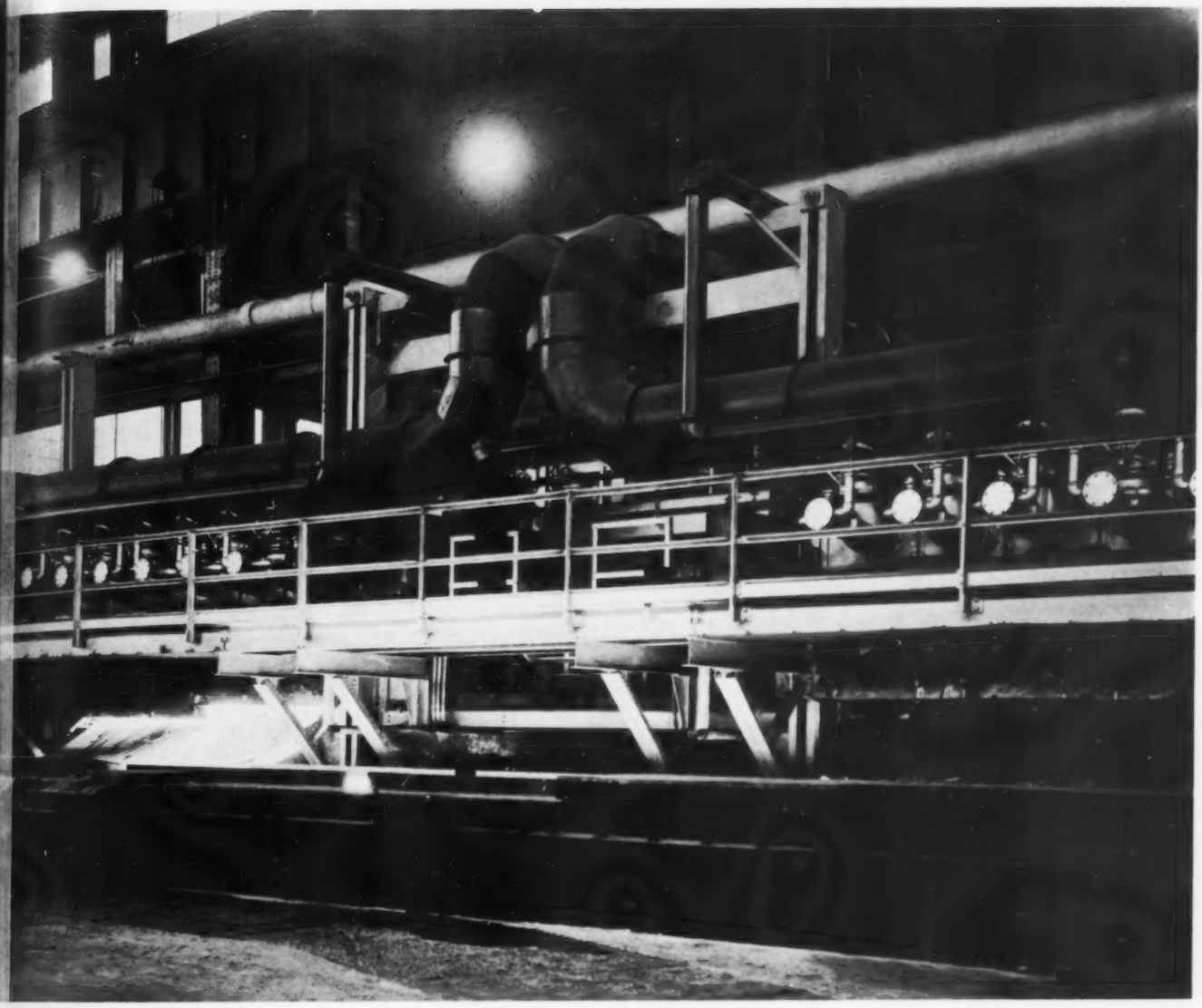
SLAB YARD

Slabs for use in the strip mill come from an existing 44″ blooming mill which lays alongside the slab storage building. Slabs average about 40″ x 4½″ x 88″ in size, with a maximum of 43½″ x 5″ x 88″. Immediately following the slab shear in the blooming mill there is a transfer which takes slabs into the slab storage. The latter building is 55 ft. wide x 690 ft. long, and is served by three overhead cranes, each of 25 tons capacity, with 10 ton auxiliary hoists. One end of the building is taken up by the charging tables of the hot mill furnaces, which project back into the slab storage.

Slabs are placed, by the overhead cranes, onto the magazine pusher, which is lift operated, through a rack and pinion arrangement, so as to raise just enough to allow one slab to be pushed off on to a roller table, 56 feet long, which runs across the back of the three hot mill furnaces, and conveys the slab to whichever furnace desired. Each furnace is equipped with a double unit pusher having two arms, which can be operated separately or can be mechanically locked together. Usually, however, they are operated separately, as the furnaces are usually charged with double rows of short slabs.

FURNACES

There are three triple-fired continuous slab heating furnaces, end charged, end discharged, equipped with integral refractory tile recuperators. Each furnace has an overall length of 82′–4″, a hearth length of 76′–10″,



Partial view of the three triple-fired continuous slab heating furnaces. These furnaces have a capacity of 50 tons of cold steel per hour.

and a hearth width of 18′, with a capacity of 50 tons of cold steel per hour. The main heating chamber is 61′–11″ long, and is fired with six long flame type burners spaced across the width of the furnace above the steel, and six similar burners similarly spaced below the steel. The soaking chamber is 14′–11″ long, and is over-fired with six burners spaced across the furnace width. The burners can use natural gas, coke gas, or a mixture of the two. It is also possible to use oil as an auxiliary fuel. Combustion air is delivered from the refractory tile recuperators at temperatures of about 750 degrees F. and is pushed under pressure to the burners by a high-temperature fan, motor driven and direct connected. Fuel input to the furnaces is manually controlled. Gas and air pressures are regulated by automatic controls. The furnaces are fully insulated, except for a short section of the roof immediately over the burners of the main heating chamber. Water-cooled skid rails and supporting pipes are used, so insulated by a special construction as to reduce heat loss and cooling water requirements. Skids are supported on refractory piers.

HOT MILL

Slabs are discharged from the heating furnaces, at temperatures approximating 2250 degrees F., by gravity, and proceed down the roller table to a 2-high, 23″ x 76″ scale breaker, driven by a 1500 H.P., 2200 volt, 270 R.P.M., A.C. motor, Primary scale is cracked by very slight reduction in this pass, and removed by hydraulic jets at 1000 lb. per sq. in. pressure. Then follows a 4-high, 36″ and 49″ x 96″ stand, driven by a 3000 H.P. 6600 volt, 150 R.P.M. induction motor with built-in flywheel. Preceeding this stand is a turn table, which turns the slab through 90 degrees for broadside or cross rolling in this first stand. Cross rolling is used only when the desired width of the finished material

THE YOUNGSTOWN SHEET AND TUBE CO. YOUNGSTOWN

W. B. GILLIES
Vice President in charge of Operations.

A. W. SMITH
District Manager.

is greater than the maximum width of slab available. A second turntable follows the broadside stand to return the slab to its original axis for subsequent rolling. To assist the slabs to enter the spreading stand, there is a heavy slab pusher of the screw type, supported above the roller table between the scale breaker and the spreading stand.

The slab next enters a hydraulically operated squeezer, where it is flattened in order to assure easy entry to the rolls of the following stands, and at the same time squared and trued as to width.

Following this are three more roughing stands. These stands are 4-high, 24″ and 49″ x 79″, each driven by a 6600 volt, 514 R.P.M. induction motor, the first two of 3000 H.P. each, with flywheels, and the third, 5000 H.P., without flywheel. These stands are so spaced that the slab is in only one stand at a time. Center line distances of the roughing stands, from the scale breaker on, are successively 31′–4″, 40′–11″, 46′–6″, and 70′–6″. Hydraulic jets at 1000 lb. pressure are used after the second roughing stand to remove secondary scale.

On the entry side of each of the last three roughers are located vertical edging rolls, integral with the mill stand itself. The edging rolls are driven by 150 H.P. 230 volt, D.C. motors, 450/900 R.P.M., mounted on top of the mill housing.

Between the roughers and the finishing train there is a roller table 98′–11″ long. The finishing train is composed of a 2-high, 24″ x 79″ scale breaker, and six 4-high, 24″ and 49″ x 79″ stands. The scale breaker is driven by a 500 H.P. 600 volt D.C. motor, 150/450 R.P.M., and each finishing stand by a 3500 H.P. 600 volt D.C. motor, 175/350 R.P.M. Hydraulic jets at 1000 lb. pressure follow the scale breaker. Electrically operated loopers are located between each finishing stand, as well as guides to assure proper entry into the mills.

The finishing stands are located on the closest centers practicable, 18 feet, this being largely determined by

C. A. DAVIS,
Assistant General Superintendent

J. L. MAUTHE,
Assistant General Superintendent.

F. A. ROBERTS,
Assistant to the District Manag

J. K. S
tant Manage

dimensional requirements of the motors and gear sets. All stands of the mill drive through gear reduction sets with separate pinion stands.

Screwdowns are electrically operated, and so arranged that each side of a mill stand may be adjusted separately, or both sides adjusted together, from push buttons located on the mill housing, thus making mill adjustments very convenient.

Closely following the last finishing stand, and synchronized with it, is a rotary flying shear which will cut material leaving the mill to any predetermined length. Cut lengths from the shear may proceed down the run-out table for approximately 800 ft., where a set of pinch rollers and a sheet piler are located.

In the case of plates or heavy gauge sheets, a lateral cooling transfer, 258 ft. long, and located about 50 ft. beyond the flying shear, may be used to carry the product to another roller line paralleling the run-out table. This roller line includes a roller leveller and plate shear, and at the far end, a second leveller, a flying shear, and a sheet piler. Just ahead of the second leveller there is another lateral transfer, by means of which heavy material may be returned to the run-out table and moved back towards the mill to a roll-off table, where it may be removed and piled for cooling.

Located in the run-out table 386 ft. from the last finishing stand, just after the first lateral transfer and just ahead of the roll-off table, are two hot coilers which can be used to coil material direct from the mill. The coils have an inside diameter of 24 inches and a maximum outside diameter of 44 inches. Coils are discharged from the coilers and placed on a chain conveyor, which carries them to the coil storage building, where they are weighed and stored. This building is 124 ft. x 280 ft., and is served by two 15 ton cranes.

The mill is operated and controlled for the most part from the various elevated pulpits located on the building walls along the mill. It is equipped with all the necessary instruments for complete metallurgical control of

J. D. JONES,
Chief Engineer.

J. INGERSOLL,
Superintendent Blooming and Skelp Mills

J. K. SUTHERLAND,
Assistant Manager of Youngstown District.

A. S. GLOSSBRENNER,
Superintendent of Hot Strip Mill.

J. S. STANIER,
Superintendent of Cold Mill.

R. E. LEWIS,
Electrical Superintendent

F. E. LEAHY,
Fuel Engineer.

J. H. KREHL,
Mechanical Superintendent.

A. G. McHUGH,
Assistant Chief Engineer.

E. C. MARSHALL
Electrical Engineer.

the steel passing through the mill, so that these properties may be accurately maintained, as well as the gauge, size, etc.

The hot mill building proper is 84 ft. wide x 632 ft. long, while the run-out building is 87 ft. x 826 ft. The former is served by two 60 ton cranes with 25 ton auxiliary hoists, and the latter by three 15 ton cranes.

MOTOR ROOM

The hot mill motor room lies alongside and between the slab storage and the hot mill buildings. It is a brick-walled building 54 ft. wide x 440 ft. long, and contains the twelve main drive units previously mentioned, together with their respective gear reduction sets.

All motors of the finishing train are 600 volt D.C. adjustable speed, shunt wound motors, and total 21500 H.P. connected D.C. load. To supply this power, there are installed two 6000 K.W. motor-generated sets, each consisting of two 3000 K.W. 40 degree C., 600 volt D.C. generators, and each driven by one 8600 H.P. 6600 volt, 60 cycle, 80% P.F., 360 R.P.M. synchronous motor. D.C. power for general purposes is furnished by two motor-generators, each consisting of a 1000 K.W. 250 volt D.C. generator driven by a 1440 H.P. 80% P.F., 514 R.P.M., 6600 volt 3 phase, 60 cycle synchronous motor.

Smaller units employed on the hot mill include the following:

One 375 K.W. 4 unit M.G. set for main drive excitation.

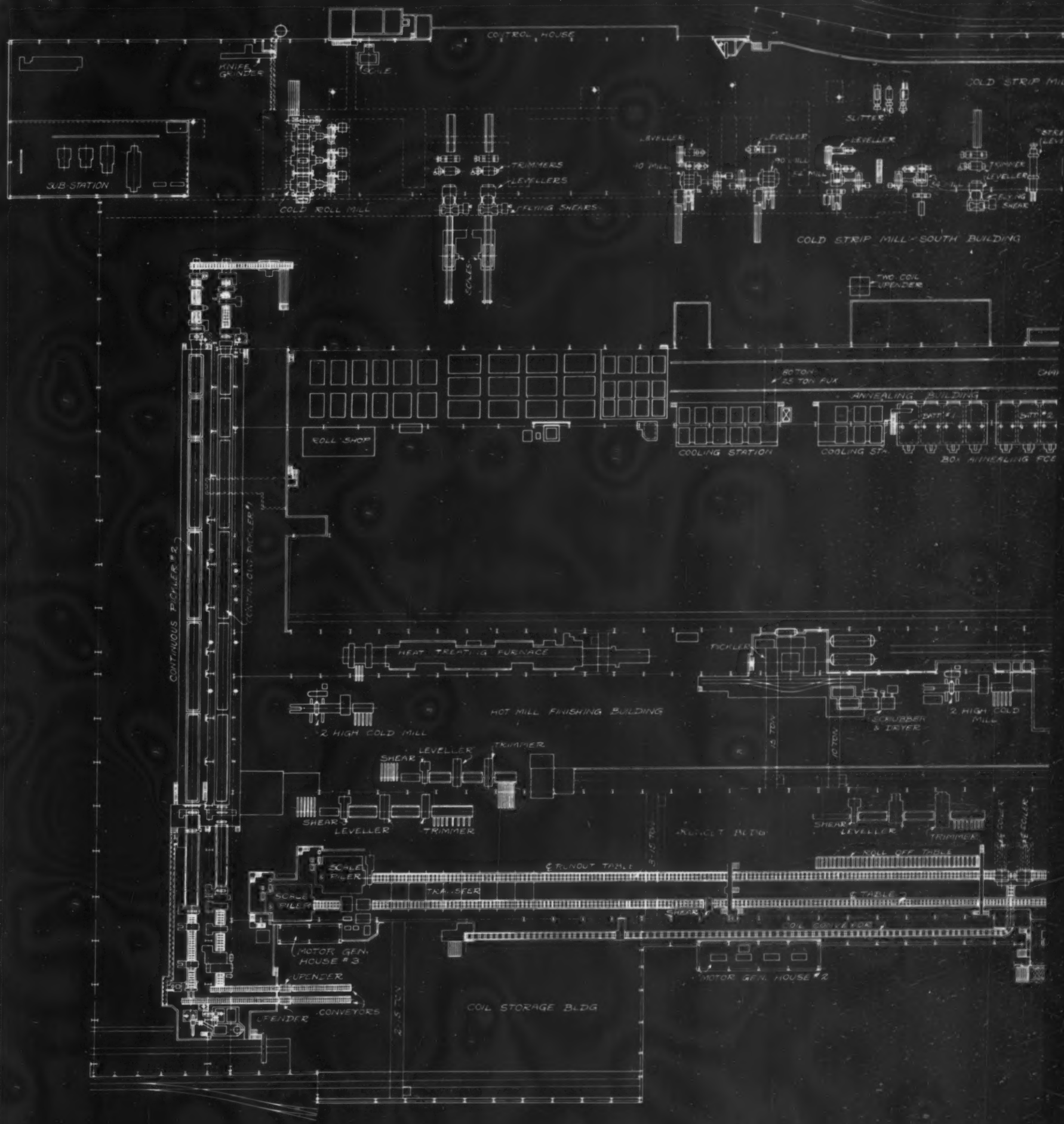
Two 25 K.W. 50 volt, 1750 R.P.M. 2 unit induction motor generator sets for the looper motors.

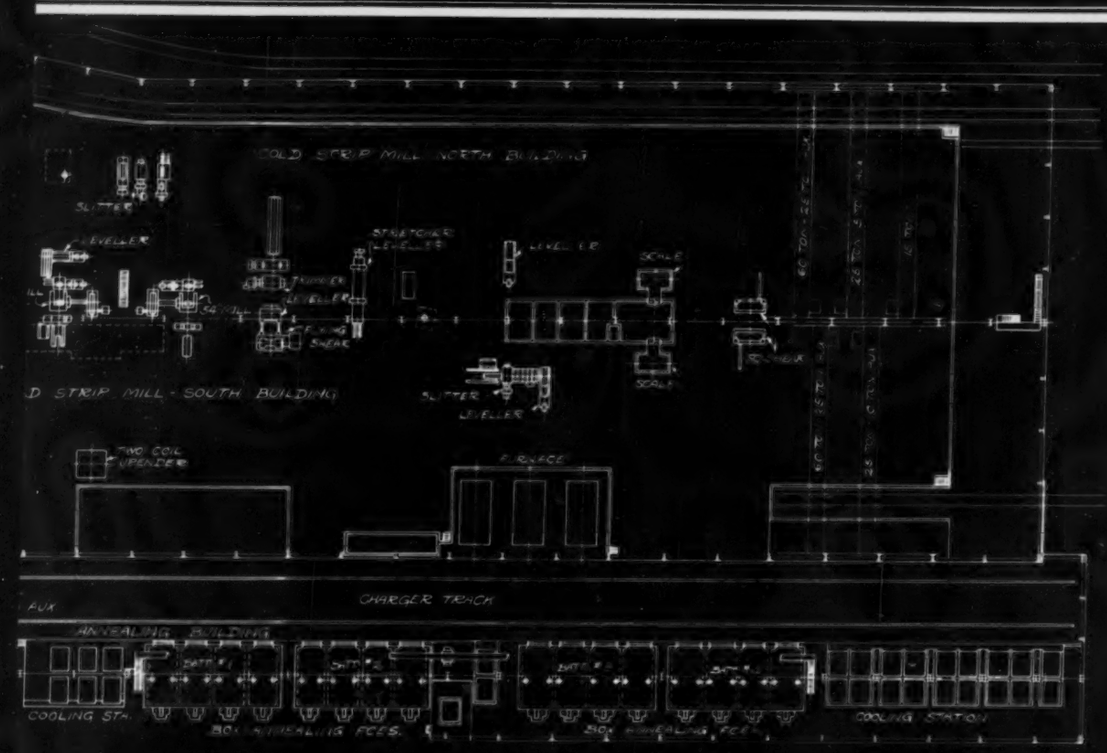
One 520 K.W. 3 unit, 600 volt, 720 R.P.M. synchronous M.G. set for the flying shear.

Four 125/360 K.W. 2 unit, 400/1200 R.P.M. variable frequency M.G. sets for run-out table motors.

One 50 K.W. 2 unit, 32 volt, 1150 R.P.M. for dynamic braking on run-out table motors.

Two 50/135 K.W. 2 unit 400/1200 R.P.M. variable frequency M.G. sets for coiler motors.


CONTROL HOUSE
KNIFE GRINDER
COILE
SUB-STATION
COLD ROLL MILL
TRIMMERS
LEVELLERS
FLYING SHEARS
SCALES
COLD STRIP MIL
SLITTER
LEVELLER
LEVELLER
LEVELLER
TRIMMER
LEVELLER
FLYING SHEAR
COLD STRIP MILL - SOUTH BUILDING
TWO COIL UPENDER
ANNEALING BUILDING
COOLING STATION
COOLING STA.
ROLL SHOP
CONTINUOUS PICKLER #2
CONTINUOUS PICKLER #1
HEAT TREATING FURNACE
HOT MILL FINISHING BUILDING
2 HIGH COLD MILL
PICKLER
SCRUBBER & DRYER
2 HIGH COLD MILL
SHEAR
LEVELLER
TRIMMER
SHEAR
LEVELLER
TRIMMER
SCALE & PILER
SCALE & PILER
RUNOUT TABLE
TRANSFER
SHEAR
COIL CONVEYOR
MOTOR GEN. HOUSE #3
UPENDER
UPENDER
CONVEYORS
COIL STORAGE BLDG
MOTOR GEN. HOUSE #2


COLD STRIP MILL NORTH BUILDING
SLITTER
LEVELLER
STRETCHER LEVELLER
LEVELLER
SHEAR
SCALE
SCALE
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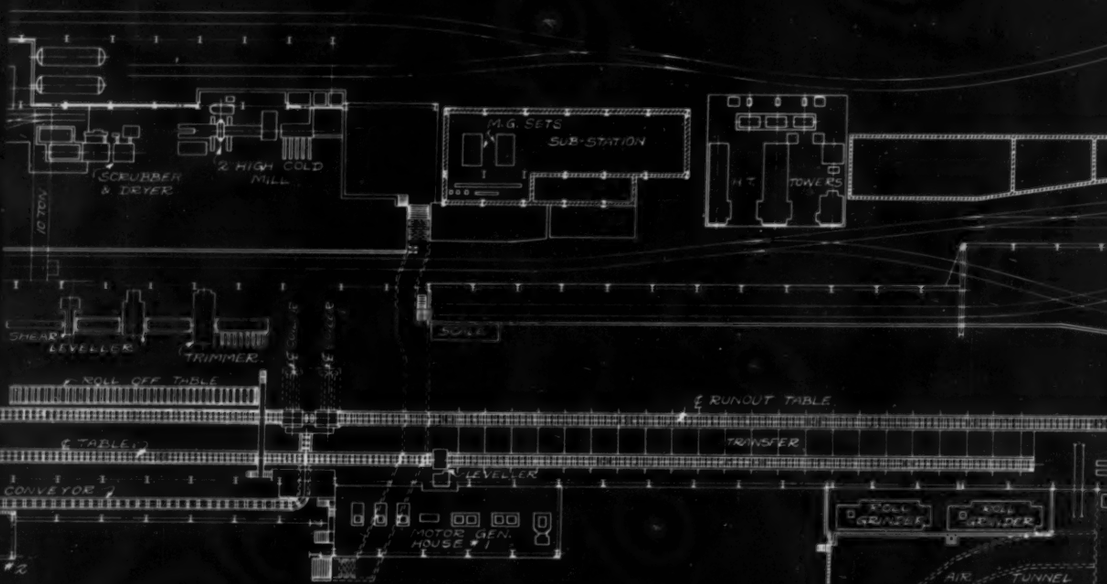
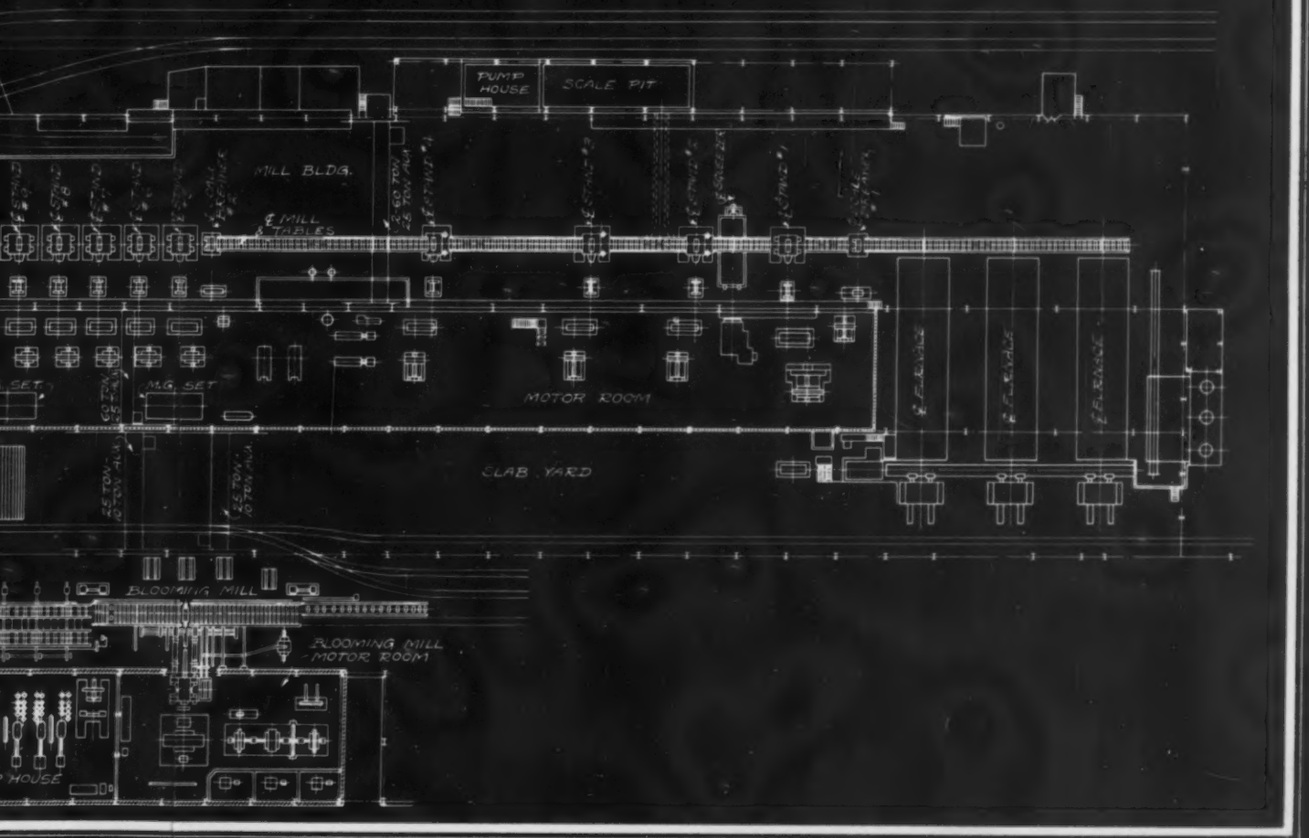

M.G. SETS
SUB-STATION
H.T.
TOWERS
SCRUBBER & DRYER
2 HIGH COLD MILL
SHEAR
LEVELLER
TRIMMER
ROLL OFF TABLE
RUNOUT TABLE
TRANSFER
TABLE
CONVEYOR
LEVELLER
MOTOR GEN. HOUSE
ROLL GRINDER
ROLL GRINDER
AIR TUNNEL
M.G. SET
PUMP HOUSE

PLAN VIEW
BLOOMING MILL
HOT AND COLD STRIP MILLS
THE YOUNGSTOWN SHEET & TUBE CO.
AMPBELL WORKS, YOUNGSTOWN OHIO



Three 45/135 K.W. 420/1440 R.P.M. 2 unit variable frequency M.G. sets for cooling bed run-out table motors.

Four 4/10 K.W. 2 unit 420/1440 R.P.M. variable frequency M.G. sets for cold flying shear table motors.

Also located in the main motor room are two centrifugal pumps of 1000 G.P.M. capacity at 1000 lb. pressure, driven by 900 H.P. motors, as well as the switchboard and control equipment for the hot mill units and auxiliaries.

The entire motor room is kept under pressure by air pumped in at a rate of 350,000 c.f.m. from the outside through filters of the oil-coated, impingement type, and conducted through a tunnel into a pressure room, from which it is vented up through the large electrical units into the motor room. The fans and air filters are located in a brick building at the west end of the slab yard and south of the motor room. The tunnel from this building to the motor room basement is about 300 ft. long.

The hot mill roll shop is located in the west end of the motor room. The equipment in this shop consists of one 50″ roll lathe and two 53″ roll grinders. Rolls are transferred from the hot mill to the roll shop and back on a transfer car moved by an electrically driven car puller.

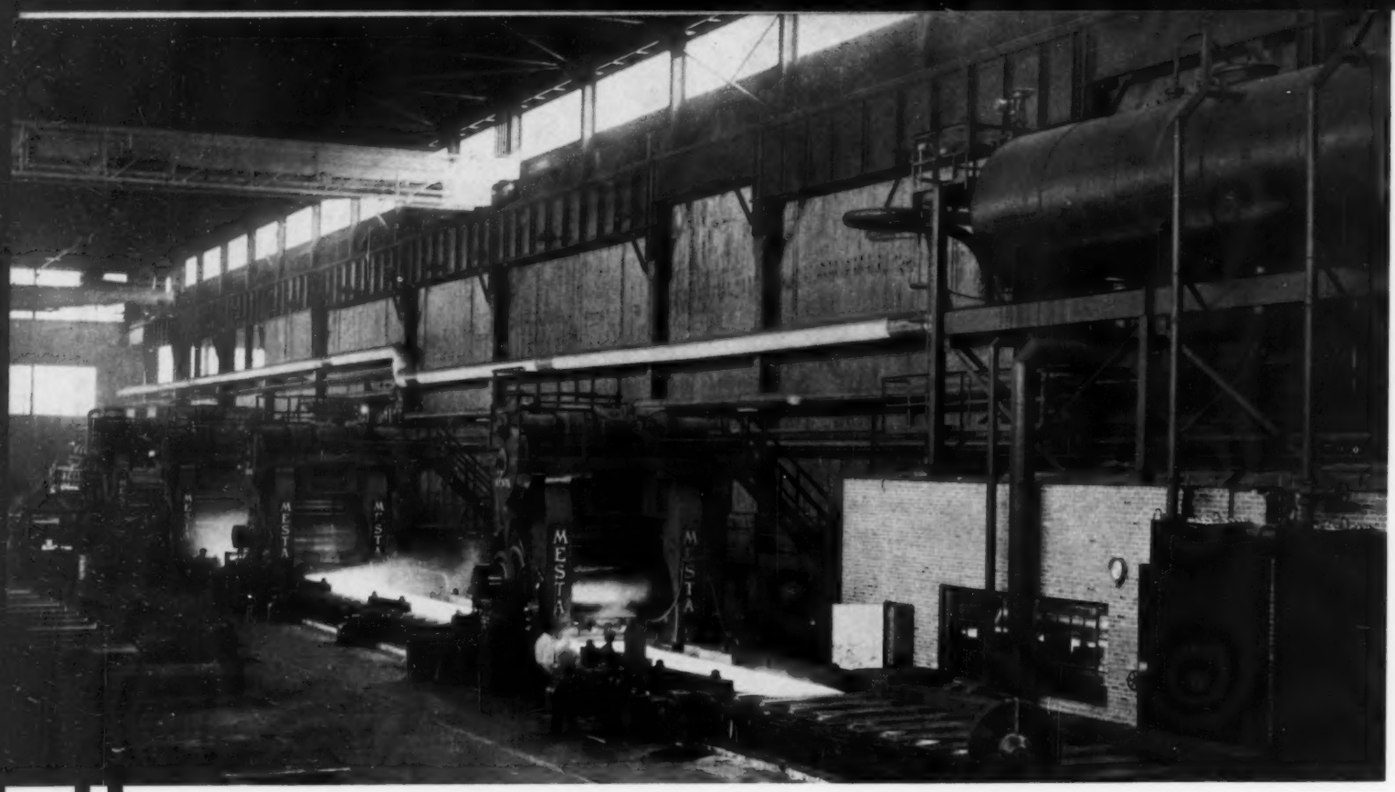
FINISHING OPERATIONS

Located along the north side of the run-out building are two tandem trimming units, each consisting of a side shear, a roller leveller, and a finishing shear. These units handle strip up to the maximum width produced on the hot mill, and up to approximately 25 ft. in length. One unit is used for strip $\frac{5}{16}$″ thick and under, and the other for strip $\frac{3}{16}$″ and under.

Paralleling the run-out building on the north is the hot mill finishing building, 80 ft. wide x 586 ft. long, with a lean-to 29′–3″ wide x 586 ft. long. In this building are housed two 2-high skin pass mills, 29″ x 78″, each placed in tandem with a backed-up roller leveller; one tandem trimming, levelling and shearing unit for $\frac{3}{16}$″ gauge and lighter; four 156″ resquaring shears; one four-armed vertical plunger mast type sheet pickler, with sheet scrubbing and drying unit; and one continuous radiant gap heat treating furnace of the hot bottom type. This furnace is 9 ft. wide x 125 ft. long. The primary heating zone is 100 ft. long and the secondary, 25 ft. long with a removable roof. Sheets are carried through the furnace on five roller chains to which are attached heat-resisting alloy carrier fingers. The chains are supported on steel supports which also hold the furnace bottom, the carrier fingers extending upward through continuous slots in the furnace bottom. The chain sprocket wheels are mounted on the head

TABULATION OF MILL AND DRIVE DATA

Mill	Characteristics	Roll Dia.	Roll Length	Motor H.P.	Volts	Motor RPM	Motor Type	Remarks
HOT MILL								
Scale breaker	2-high, 1-stand	23″	76″	1500	2200	270	Ind.	Geared.
Broadside	4-high, 1-stand	36″ & 49″	96″	3000	6600	150	"	"
Rougher	4-high, 1-stand	24″ & 49″	79″	3000	6600	514	"	"
"	4-high, 1-stand	24″ & 49″	79″	3000	6600	514	"	"
"	4-high, 1-stand	24″ & 49″	79″	5000	6600	514	"	"
Scale breaker	2-high, 1-stand	24″	79″	500	600	150/450	DC	"
Finisher	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
"	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
"	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
"	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
"	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
"	4-high, 1-stand	24″ & 49″	79″	3500	600	175/350	"	"
COLD MILL								
Tandem Mill	4-high, 3-stand	20½″ & 49″	75″	(3) 1250	600	300/600	DC	Coils only.
Cold Mill	4-high, 1-stand	20½″ & 49″	75″	1250	600	300/600	"	For coils or sheets.
" "	4-high, 1-stand	20½″ & 49″	93″	1250	600	300/600	"	Sheets only.
Skin Pass Mill	2-high, 1-stand	27″	54″	250	230	500/1000	"	Coils only.
" " "	2-high, 1-stand	27″	54″	250	230	500/1000	"	For coils or sheets.
" " "	2-high, 2-stands	29″	78″	....	....	.....	DC	In hot mill finish. bldg.



Panoramic view of the roughing end, 79″ continuous hot strip mill which went into operation March 1935. A total of 19,000 HP is necessary to drive the stands in this roughing train.

Close up view of the last stands in the roughing end. These stands are so placed that the slab is in only one stand at a time.

THE YOUNGSTOWN SHEET AND TUBE CO.
YOUNGSTOWN

shaft at the discharge end of the furnace. Counterweighted take-ups at the charging end of the furnace take up slack in the chains. The conveyor is driven by motor through a reduction gear unit. The furnace is fired with natural gas through six burners placed in the primary zone, and one burner in the secondary zone.

A depressed railroad track and a truck platform, also located in this building, provide shipping facilities direct from this point.

CONTINUOUS PICKLERS

The pickling building is located at right angles to, and across the west ends of the coil storage, run-out, and hot mill finishing buildings. Charging conveyors of the picklers project over into the coil storage building, while the discharge ends project slightly into the cold mill building. The pickler building, which is about 95 ft. wide x 580 ft. long, was provided by the alteration of existing buildings.

Coils are handled from the coil storage by magnets on the overhead cranes in the latter department, onto gravity conveyors. The coils then proceed to an upender, which turns the coils onto their sides and discharges them onto a conveyor, which in turn carries them into position in front of the feed reels. The sec-

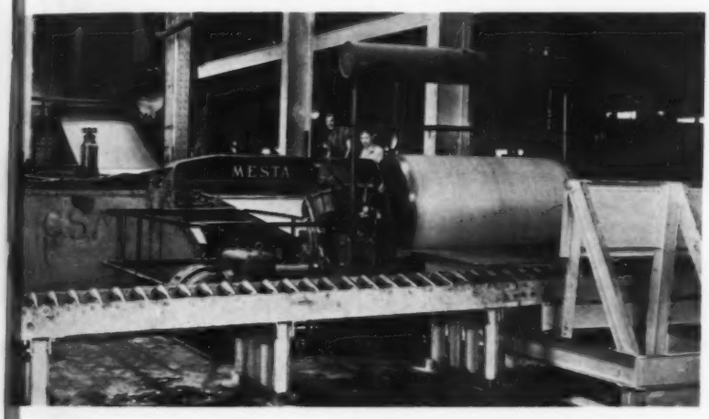
View of the hot slab in one of the stands of the roughing train.

These six finishing stands are driven by a total of 21,000 HP. All stands of the mill are driven through gear reduction sets with separate pinion stands.

THE YOUNGSTOWN SHEET AND TUBE CO. YOUNGSTOWN

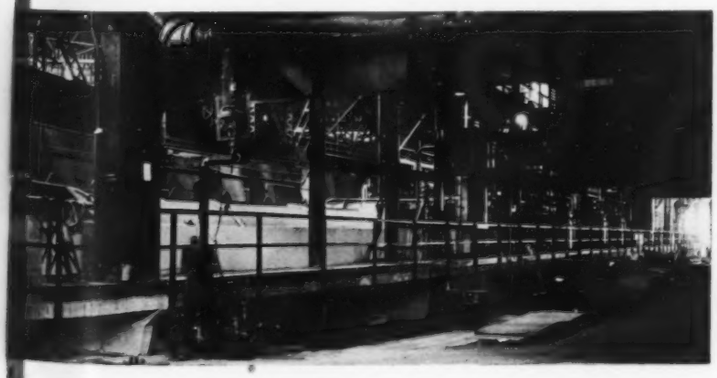
Some idea of the size of the finishing stands may be gleaned from this close up view. The combined weight of these stands in the finishing train is 5,000,000 pounds.

View of roll tables and coilers. These tables are approximately 800 feet long.



Delivery end of continuous pickler. Gravity conveyors transport the recoiled material to the cold mill building.

Another view of continuous pickler. This pickler is 380 feet in length.



tion of the conveyor immediately in front of the feed reels tilts up to discharge the coils onto a runway leading to the feed reels.

There are two continuous pickling units, with provisions for a third, to be installed at some future date.

One pickling unit consists of a feed reel, a combination processor (or scale cracker) and straightener, an upcut shear, a mechanical stitcher, pinch rolls, and a looping pit, followed by another set of pinch rolls for feeding the strip through the pickler.

There are four acid tanks, each 60 ft. long by 84″ wide, followed by two wash tanks 26 ft. long by 84″ wide. Acid solution in the tanks runs 8–12% in strength, and is held at a temperature of about 180 degrees F. The first wash tank is filled with cold water and the second with hot water.

At the delivery end of the pickler are located a hot air dryer, pinch rolls, an upcut shear, an oiling machine, and a re-coiler. The strip is run through the pickler at a normal speed of about 80 ft. per min., with an extreme range of 40-160 ft. per min. After re-coiling, the coils are discharged by a gravity conveyor into the Cold Mill building.

The second unit is planned similarly to the first unit, with the exception of a changed type of feed reel and processor, and provisions for electrolytic pickling in tanks No. 2 and 3.

COLD MILLS

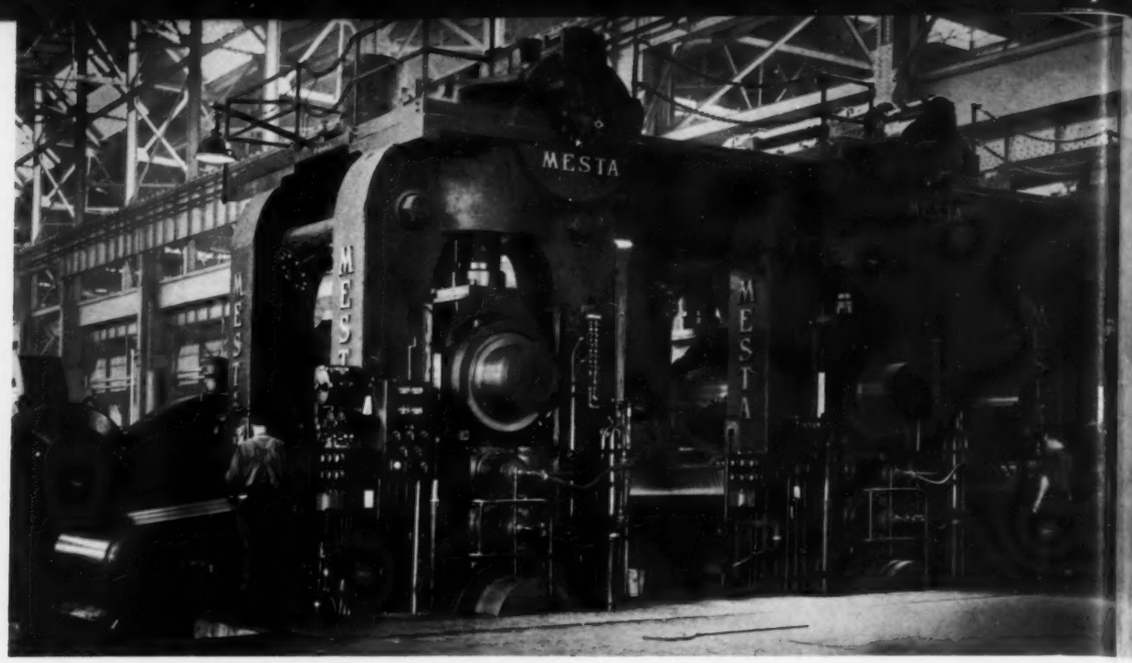
The cold mill plant consists of three buildings laying parallel to the hot mill building. The rolling mill building is composed of two spans, designated respectively as the "North" and the "South" buildings. The former is 104′–4″ wide x 1008′ long, and the latter 104′–4″ wide x 864′ long.

The equipment of the cold mill department includes one 4-high 3-stand tandem mill, with work rolls of 20½″ dia. x 75″ long, and back-up rolls 49″ dia. x 75″ long. Each stand is driven through a combination gear and pinion unit, by a 1250 H.P., 600 volt, 300/600 R.P.M., D.C. motor. The pinions are connected to the work rolls by universal type spring balanced spindles. The mill is equipped with a coil box for feeding strip to the first mill, and on the delivery side of the last stand there is an automatic tension reel, with air-operated coil stripper. The capacity of this mill is stated to be 150–250 tons in 8 hours. It will roll material up to 72″ in width.

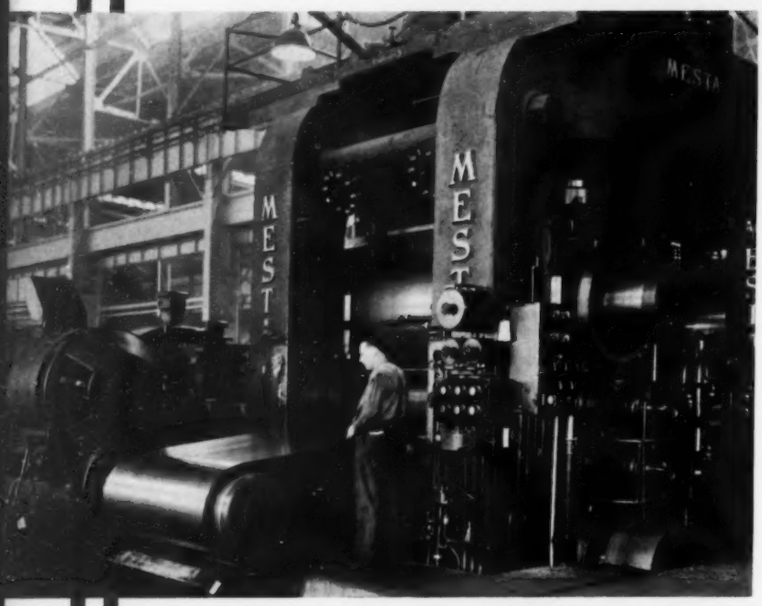
There is also installed a single stand 4-high mill, 20½″ and 49″ x 93″, driven by a 1250 H.P., 600 volt, 300/600 R.P.M., D.C. motor. This mill is equipped on the charging side with a tilting conveyor unit for feeding sheets. On the discharge side of the mill is a belt conveyor for carrying the sheets to a sheet leveller. With this unit, sheets up to 90″ wide are produced by cross-rolling up to 90″ lengths of coil coming from the tandem mill. This makes available a limited supply of sheets up to 90″ in width.

Another mill is a single stand, 4-high skin pass unit, 20½″ and 49″x75″, driven by a 1250 H.P., 600 volt, 300/600 R.P.M., D.C. motor. It is equipped with a back tension feed reel and with a tilting conveyor unit on the

THE YOUNGSTOWN SHEET AND TUBE CO. YOUNGSTOWN

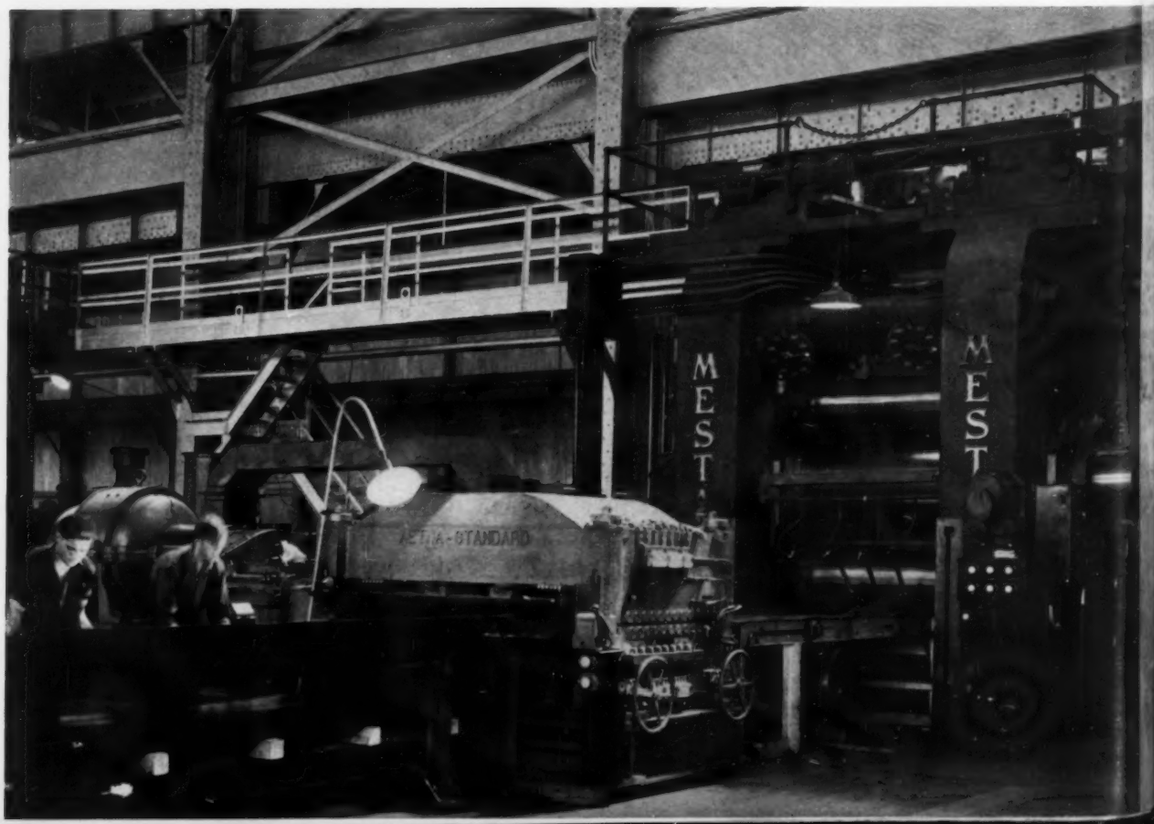


Four-high three stand tandem mill in the cold mill department. Each stand is driven through a combination gear and pinion unit by a 1250 HP, 600 volt 300/600 RPM, DC motor.

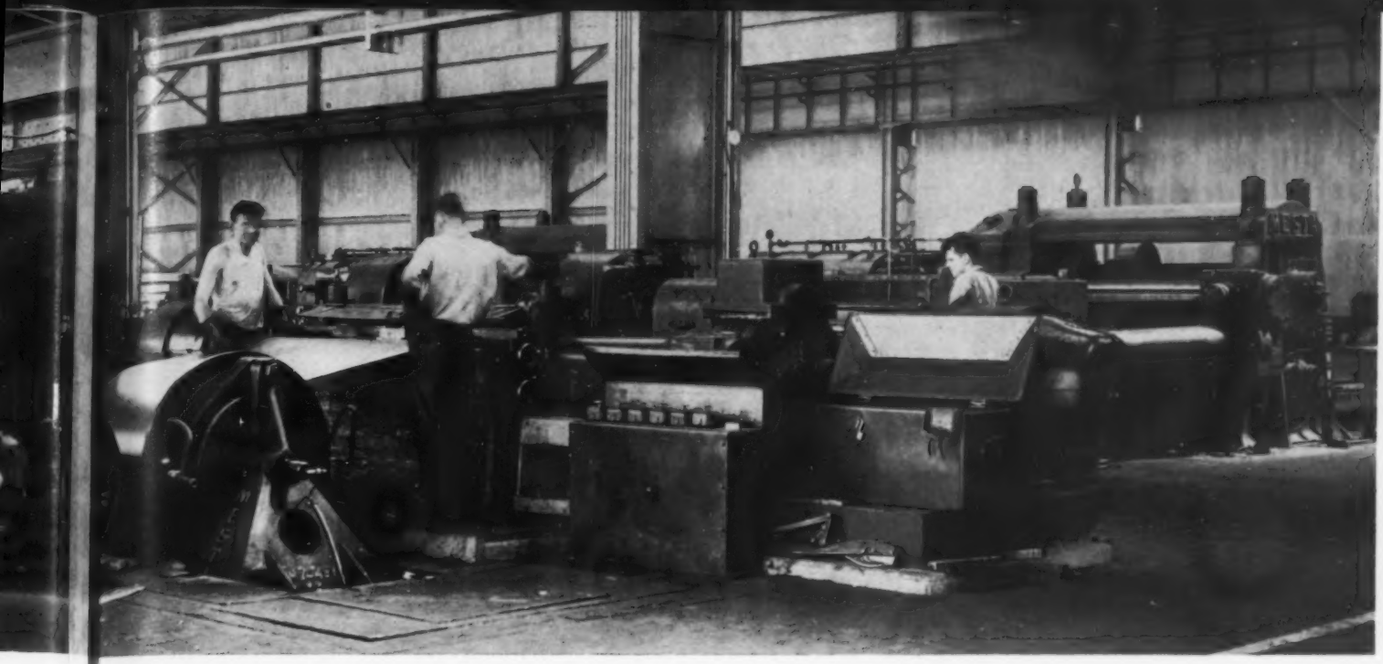


Delivery end of three stand cold mill. This view shows automatic tension reel, with air operated coil stripper. This mill will roll material up to 72" in width.

Single stand, four-high skin pass mill. This mill is also used to roll cold sheets which are too wide for the three stand tandem mill. This makes available a supply of sheets up to 90" in width.



THE YOUNGSTOWN SHEET AND TUBE CO.



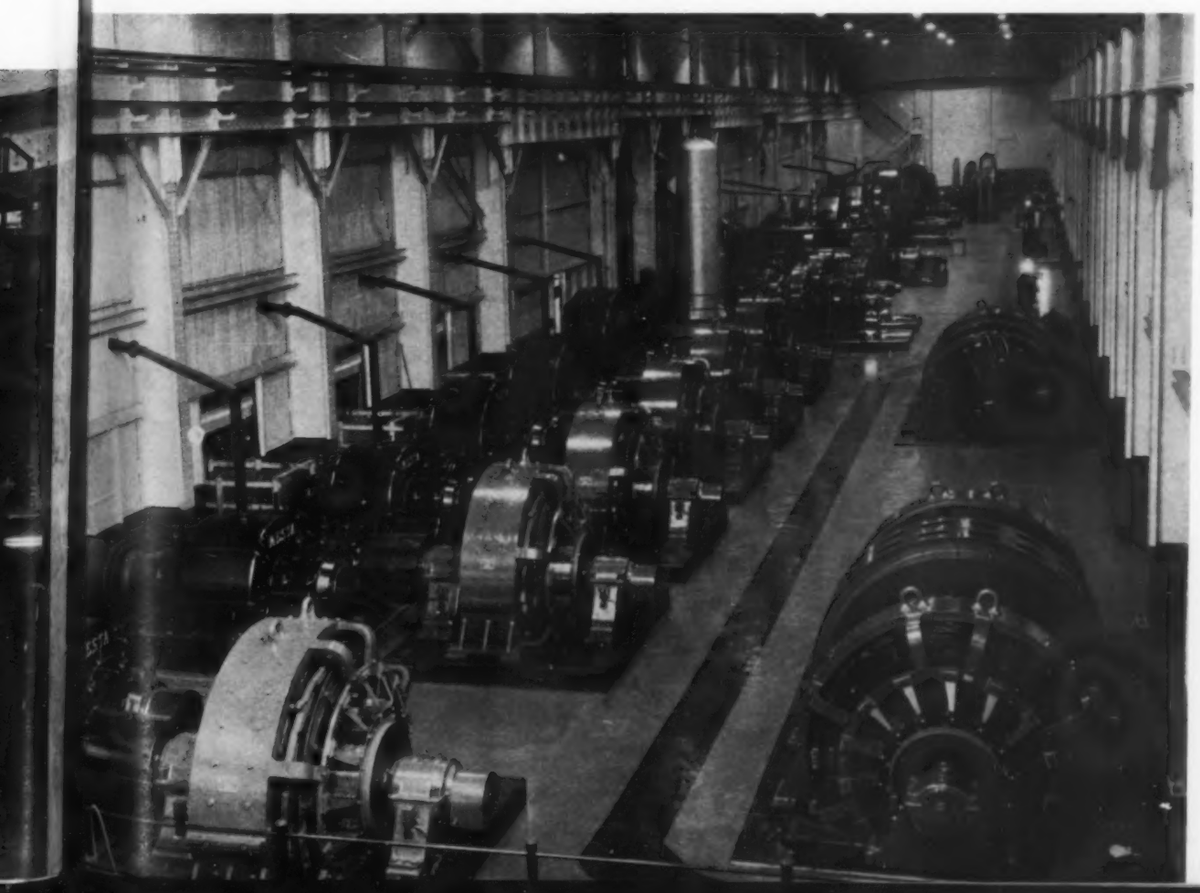
View of auxiliary equipment in the finishing department which shows one of the three cold strip cutting lines.

entry side, and an automatic tension reel and a belt conveyor on the discharge side, so that the mill can roll either coils or sheets. A sheet leveller also follows this mill.

Additional cold rolling equipment includes two 27″ x 55″ single stand 2-high skin pass mills, each driven by a 250 H.P., 230 volt, 500″1000 R.P.M., D.C. motor. One unit is equipped for rolling coils only, while the other is equipped, as the mill described above, for both coils and sheets.

Auxiliary equipment in this department includes three cold strip tandem cutting lines, each composed of feed reel, rotary side trimmer, looping table, leveller, cold flying shear, piling skids and scales; one coil slitter; one 72″ stretcher leveller; one 3½″ x 72″ roller leveller; resquaring shears, oiling machines, necessary conveyors, etc.

Motor room which houses the twelve main drive units with their gear reduction sets for the 79″ continuous hot strip mill. Also located in this motor room are two centrifugal pumps of 1000 GPM capacity at 1000 pounds pressure.



At the west end of the cold mill building is located the cold mill roll shop, which is equipped with two roll grinding lathes and one machine for shot blasting.

Power for cold mill drives is supplied by one 4400 K.W. motor generator set consisting of two 2200 K.W. 600 volt D.C. generators driven by a 5600 H.P. 80% P.F., 40 degree C., 6600 volt, 3 phase, 60 cycle, 450 R.P.M. synchronous motor. This unit is placed in the cold mill motor room, a substation 50 ft. wide x 120 ft. long located at the west end of the cold mill building. This room also houses the following equipment:

One 150 K.W. 3-unit M.G. set for main drive excitation.

One 12½ K.W. 250 volt D.C., 2-unit auxiliary booster M.G. set for the tandem mill.

Two 300 K.W. 250 volt, 2-unit induction M.G. sets, 1175 R.P.M., each driven by a 430 H.P. 2200 volt motor, for 2-high mills.

Two 20 K.W. 250 volt D.C., 2-unit, 1750 R.P.M. exciter sets for the above.

Two 750 K.W. 250 volt D.C., synchronous M.G. sets, 514 R.P.M. for auxiliary drives.

One 1000 K.W. 250 volt D.C., synchronous M.G. set, 514 R.P.M. for auxiliaries.

ANNEALING DEPARTMENT

The third building of the cold mill layout, immediately adjacent to the "South building", houses the annealing equipment. The building is 53′–4″ wide x 864′ long with lean-to. There are four batteries of box annealing furnaces, each of four chambers. Each chamber holds two boxes. These furnaces are strongly reinforced and fully insulated, and are completely equipped with gas and air controls and recording instruments. For charging and unloading these furnaces there is a specially built charging machine which runs on a track parallel to the furnace row. This machine picks up loaded boxes from the loading stations and charges them into the furnaces, and draws the hot boxes and places them on cooling skids located along the south wall of the annealing building.

Six portable annealing covers of the radiant tube type are also installed, each with four bases. Two of these furnaces are 45½″ x 142″, one 81½″ x 114½″ and three 63½″ x 182½″. Controls and instruments are grouped in a control room along the south wall, where there are also located two deoxidizing gas preparation units, each of 15,000 cu. ft. per hour capacity.

LUBRICATION

On the hot mill, all pinions, gear sets and back-up roll bearings are lubricated by three centralized automatic oil systems, located in cellars underneath the mill floor. Each system is complete with a return storage tank of 10,000 gallons capacity, and the necessary pumps, filters, heaters and coolers. A centrifuge system is also located in the cellar, and may be connected to each of the three return storage tanks for cleaning the oil as required.

Roller bearings of the various roller tables are lubricated by hand. Centralized greasing systems, of which there are two installed, are connected to a pipe header extending along the mill, permitting lubrication of the individual roll stands by means of special lubricating equipment. The hot strip coilers are automatically lubricated with a centralized system.

In the cold mills, the pinions, gear sets and back-up roll bearings are lubricated by two centralized automatic oil systems, located in cellars under the mill floor. Each system has a storage capacity of 6000 gallons, and is equipped with the necessary pumps, filters, heaters and coolers.

Roller bearings of the tandem mill are serviced by one automatic centralized greasing system. The balance of the cold mill equipment is lubricated by manually operated systems.

TABULATION OF CRANES

Location	Number	Capacity, tons	Span.
Slab Yard	3	25/10	51′–0″
Hot Mill	2	60/25	79′–8″
Run-out Building	3	15	82′–10″
Hot Mill Motor Room	1	60/25	50′–0″
Coil Storage	2	15	120′–0″
Hot Mill Finishing Building	1	10	26′–0″
" " " "	1	15	77′–0″
" " " "	1	10	77′–0/
Pickling Building	3	10	77′–2″
Cold Mill, South Building	1	60/25	100′–0″
" " " "	1	25/10	100′–0″
Cold Mill, North Building	1	60/25	100′–0″
" " " "	1	25/10	100′–0″
" " " "	1	60/25	100′–0″
" " " "	1	25/10	100′–0″
" " " "	1	15	100′–0″
Annealing Building	1	80/25	49′–0″
" "	1		Floor charger

SHOCK ABSORBING HOOK. CAN BE SUPPLIED FOR ¾" CONDUIT
HOLLOW SET SCREWS FOR ADJUSTING LAMP FOCUS TO GIVE WIDE, MEDIUM OR NARROW CONCENTRATION OF LIGHT FOR RELATIVELY LOW, HIGH OR VERY HIGH BAYS
SOCKET VENTILATED
RAIN OR DRIP DEFLECTOR TO PREVENT LAMP BREAKAGE WHEN ROOF OR MONITOR WINDOWS LEAK
DURABLE STEEL COVER PERMANENTLY SPUN ONTO REFLECTOR TO PROTECT THE PRISMS FROM DUST
INSIDE SURFACE SMOOTH CRYSTAL GLASS, HAVING NO PERMANENT DEPRECIATION
SAFETY LOCKING RING, TO KEEP PRONG HOLDER AND LAMP CENTERED PROPERLY ON REFLECTOR.
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• HOLOPHANE COMPANY, Inc.

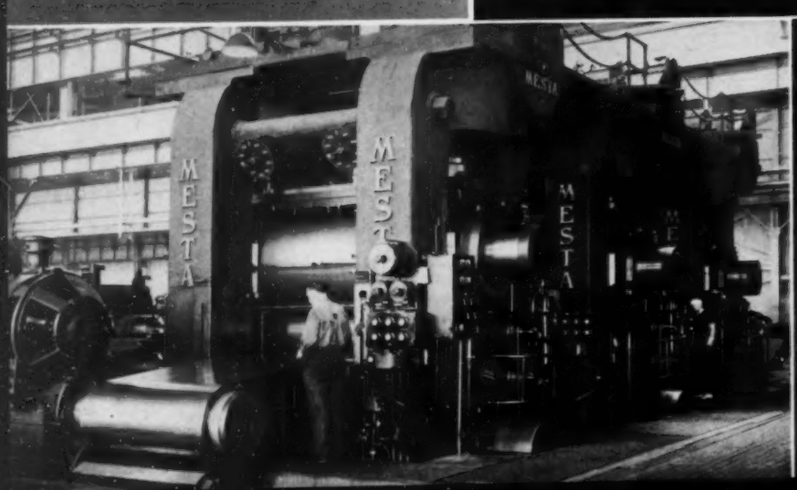
342 MADISON AVENUE, NEW YORK

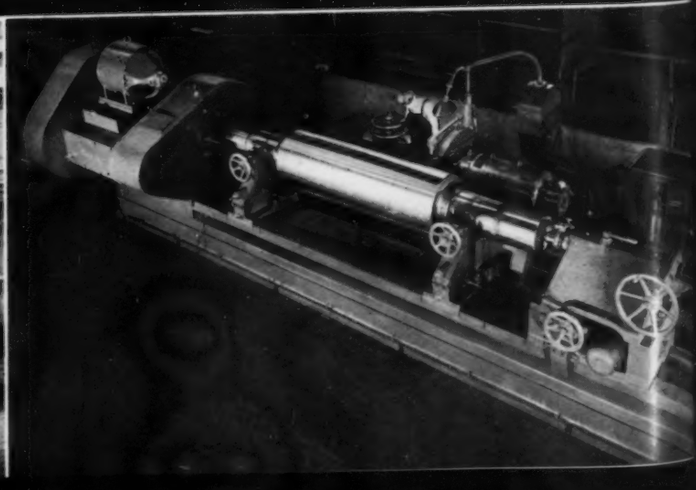
MESTA

At Youngstown Sheet & Tube Company

MESTA

STEEL MILL EQUIPMENT

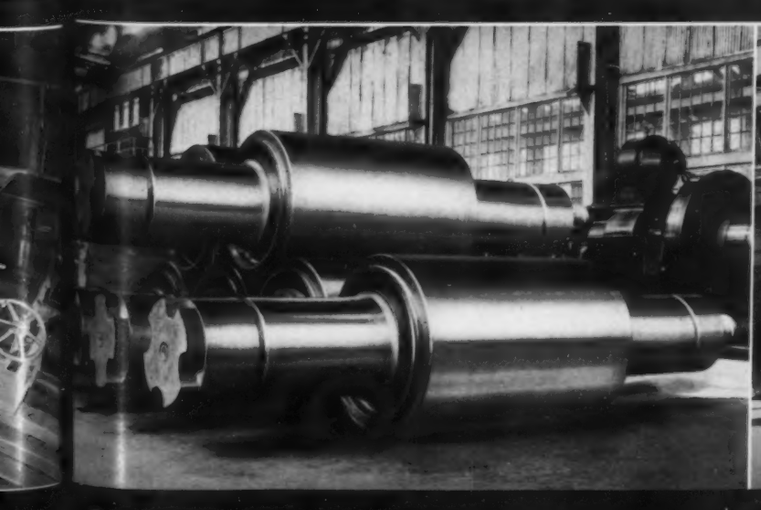




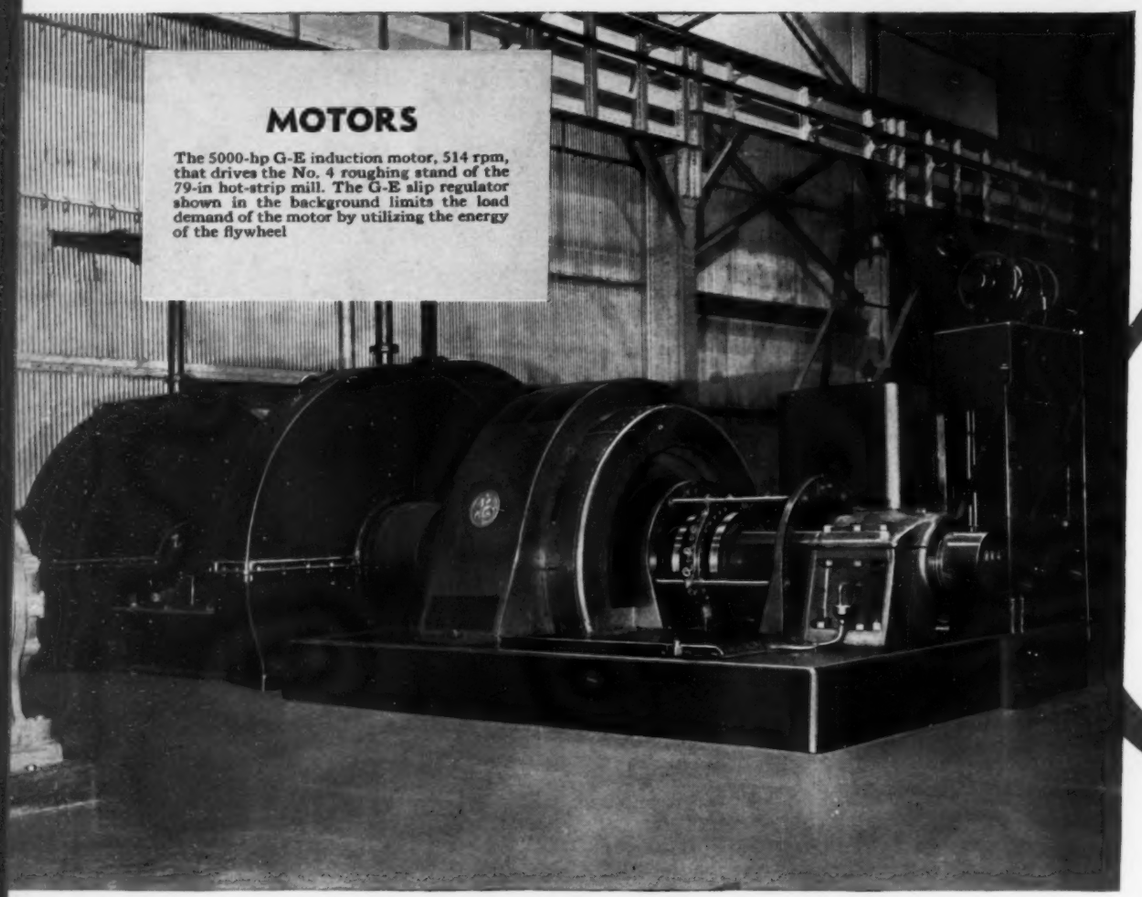
79" FOUR-HIGH CONTINUOUS HOT STRIP MILL
INSTALLED AT YOUNGSTOWN SHEET & TUBE CO.

ESTA MACHINE COMPANY

PITTSBURGH, PA.

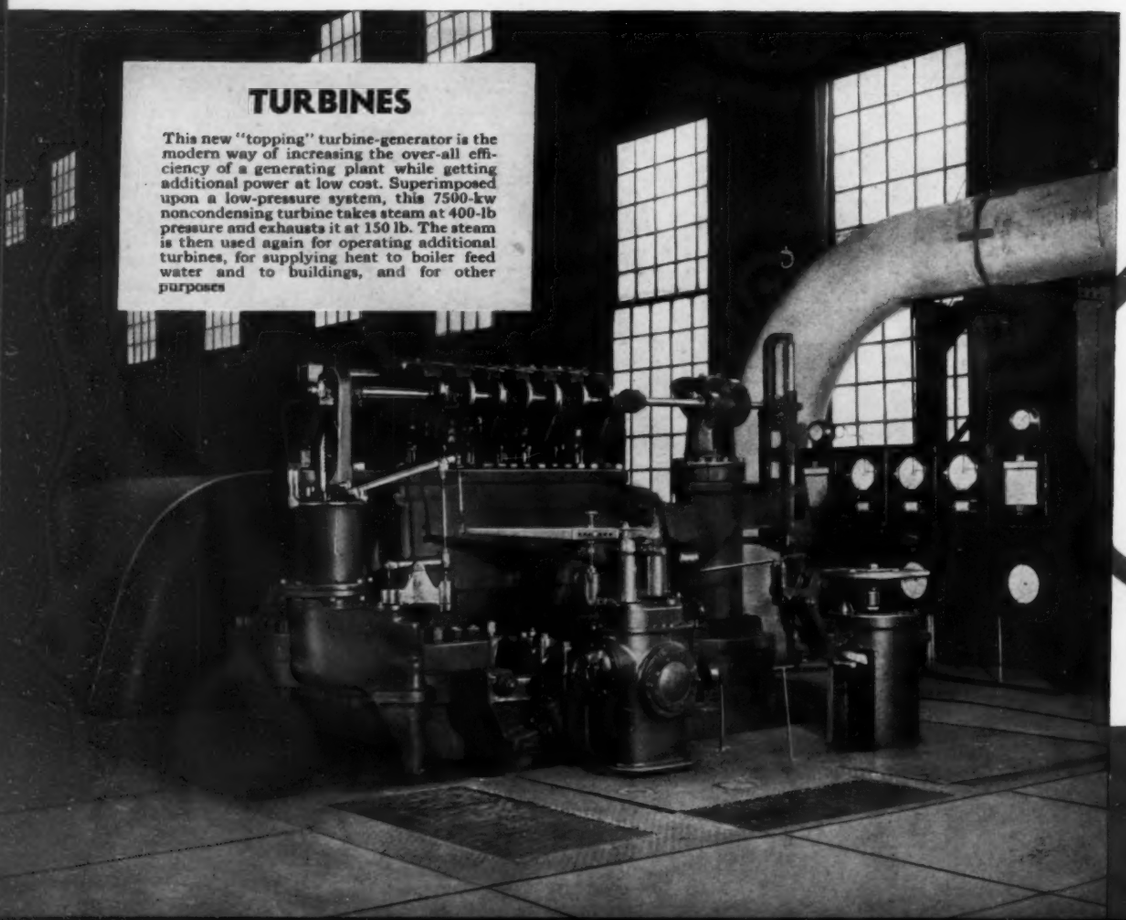


SEE THEM IN ACTION



MOTORS

The 5000-hp G-E induction motor, 514 rpm, that drives the No. 4 roughing stand of the 79-in hot-strip mill. The G-E slip regulator shown in the background limits the load demand of the motor by utilizing the energy of the flywheel



TURBINES

This new "topping" turbine-generator is the modern way of increasing the over-all efficiency of a generating plant while getting additional power at low cost. Superimposed upon a low-pressure system, this 7500-kw noncondensing turbine takes steam at 400-lb pressure and exhausts it at 150 lb. The steam is then used again for operating additional turbines, for supplying heat to boiler feed water and to buildings, and for other purposes

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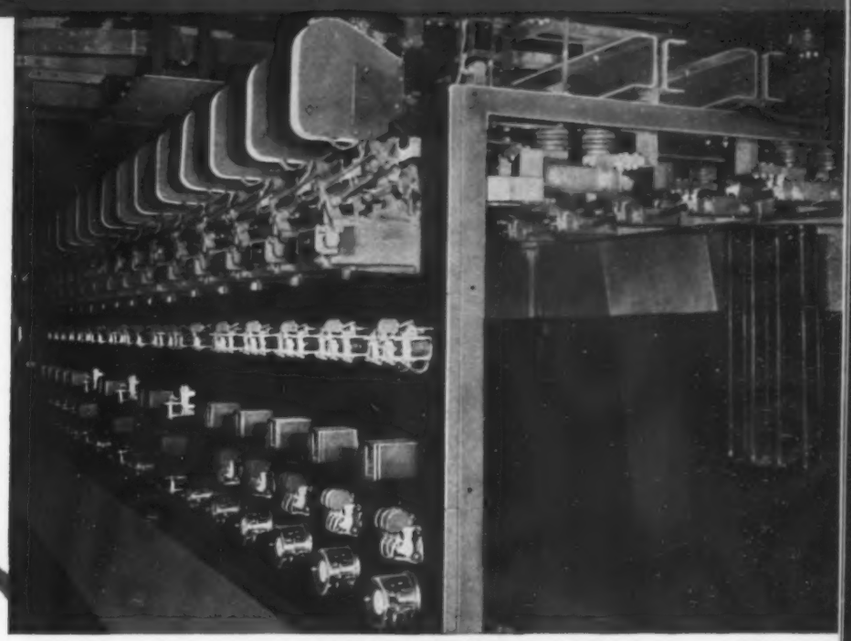
YOUNGSTOWN SHEET & TUBE COMPANY

SWITCHGEAR STEEL'S BIG 3

MC-5 Air-circuit-breaker Equipments
Metal-clad with FKR-255 Breakers
FH Breakers in Cubicles

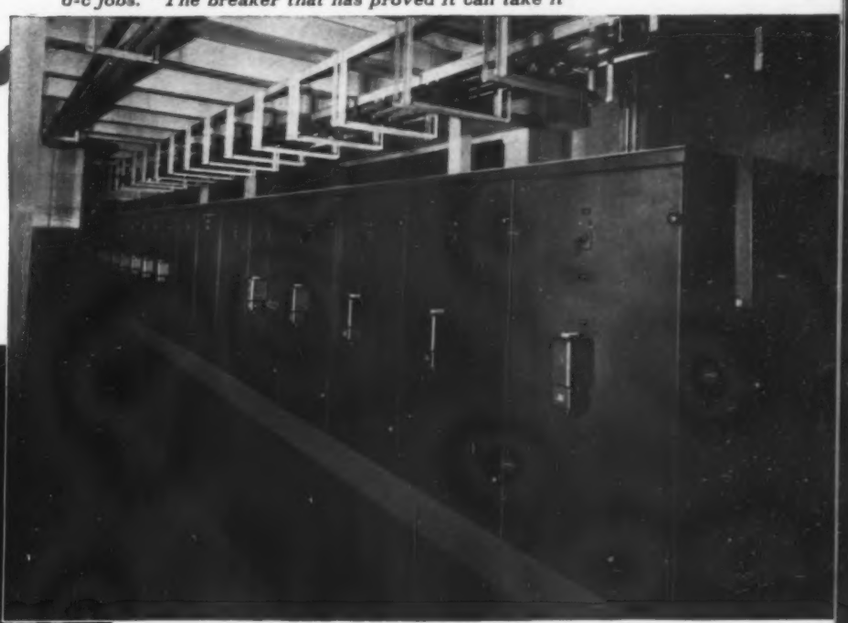
FOR YOUR MILL

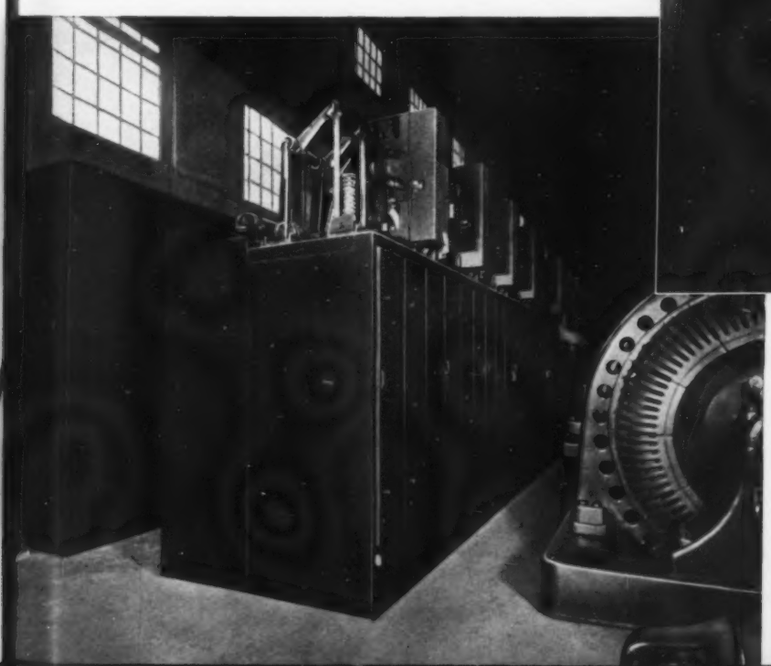
Whatever *your* requirements for electric equipment, our engineers will help you get the apparatus that best fits your needs. General Electric, Schenectady, N. Y.



IN THE COLD MILL

MC-5 air-circuit-breaker equipments for the highest capacity and toughest c-c jobs. "The breaker that has proved it can take it"





IN THE 79-INCH HOT-STRIP MILL

Metal-clad switchgear with the famous FKR-255 oil-blast circuit breakers "The steel-mill standard"

FOR THE NEW 7500-KW TURBINE

Modern FH oil-blast circuit breakers mounted in cubicles "Proved in mill service for over 30 years"

GENERAL ELECTRIC

At the Campbell Works of the YOUNGSTOWN SHEET & TUBE CO.

LINTERN PRODUCTS

Promote Safety and Savings

Glowlite

GLOWLITES

These efficient units are being used as warning signals for safeguarding workmen, as indicator lights for conveyors, cranes, furnaces and other applications, also for exits, call systems etc. They are an important safety factor and a material aid in production.

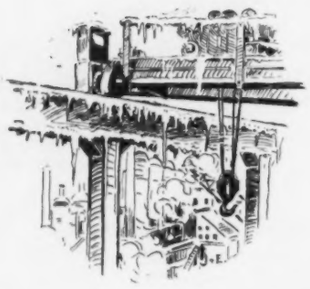
Lintern Lanterns (complete line) include sixty-one different model combinations—a lantern for every industrial need.

Overhead Crane Sander

OVERHEAD CRANE SANDERS

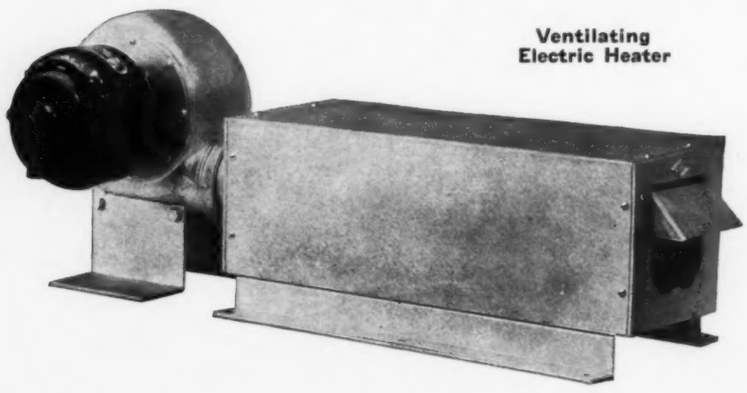
Lintern Electro-Magnetic Sanders do away with the danger of sanding by hand where a slip or a moment of thoughtlessness means injury or death.

They sand both rails evenly, saving wheel wear and crane misalignment. Since they sand while the crane is in use they do not interfere with crane operation. All they require is simply pressing a button—operator does not leave cab.



VENTILATING ELECTRIC HEATERS

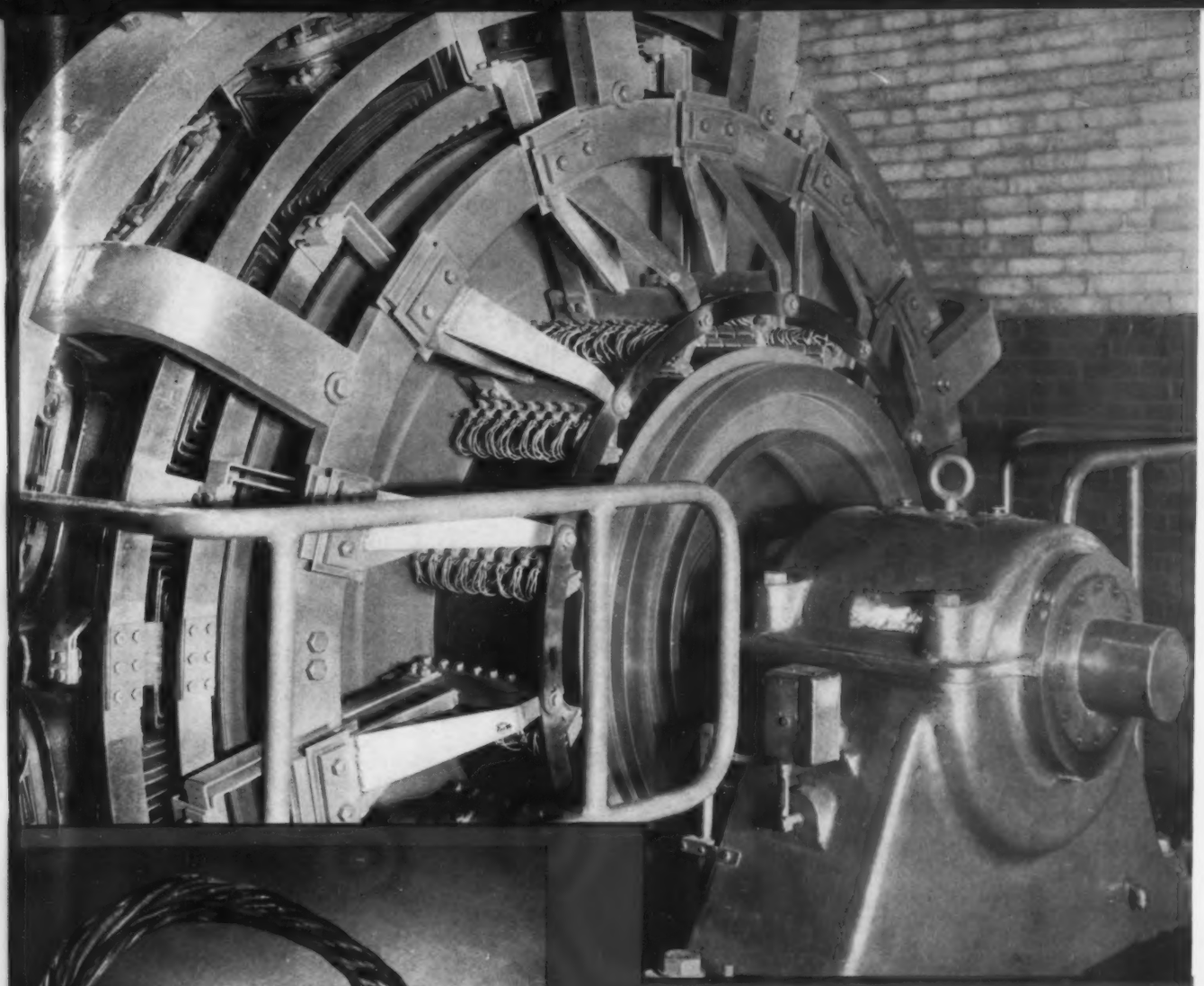
Lintern Electric Heaters represent a very modest investment. By providing comfort they add materially to the efficiency of the men and the safety of operation. They are readily portable and can be used to advantage in scores of places in the average industrial plant. On crane cab applications they combine ventilation with heating to allow the crane men to remain alert and in working condition at all times.



Ventilating Electric Heater

THE *Lintern* CORPORATION

7900 LORAIN AVE., CLEVELAND, O.



★ **LE CARBONE BRUSHES** are being used on the majority of the electrical equipment of commutating type in the Campbell Works. Le Carbone Brushes provide the highest standard of dependable, economical service, under continuous heavy loads and severe commutating conditions. They serve efficiently on all types of equipment, from the heaviest mill motors to the smallest auxiliaries.

Investigate the value of Le Carbone Brushes on your jobs.

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BOONTON, NEW JERSEY
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THE STANDARD OF QUALITY, UNIFORMITY, AND EFFICIENCY

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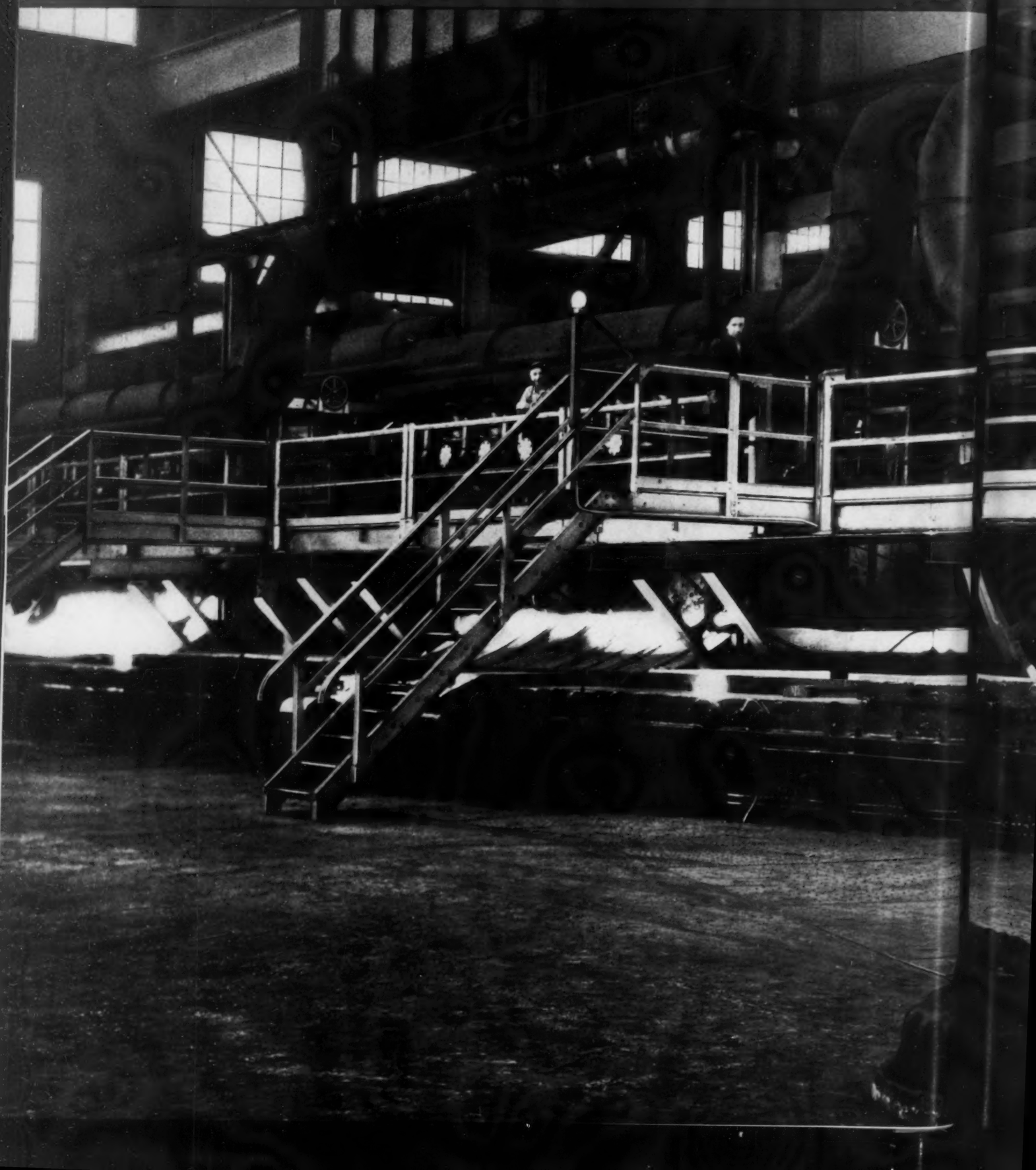
LE CARBONE BRUSHES

A BATTERY OF THREE SLAB HEATING FURNACES . .

FEEDING CONTINUOUS HOT MILL AT YOUNGSTOWN



Designed, built and erected by Surface Combustion engineers, these three triple zone, continuous slab heating furnaces are handling the production for the Youngstown Sheet & Tube Company's continuous hot mill at the Campbell Works.

These furnaces are of the end-charge-and-discharge type, 18′ wide inside and 82′ long out to out of brickwork. Each is rated at 50 gross tons per hour capacity.

Furnace burners are designed to use natural gas, coke-oven gas or a mixture of the two, and also fuel oil. Each furnace is built with an integral refractory tile recuperator from which preheated air is delivered under pressure to the burners of each firing zone by means of a high temperature, motor driven, direct connected fan. Furnaces of this design require water-cooled skid-rails and water-cooled supporting pipes. To reduce heat loss and water requirements, the water-cooled members are insulated by a special construction. Insulation is provided on roofs, sidewalls and hearths. As a result these furnaces are extremely economical.

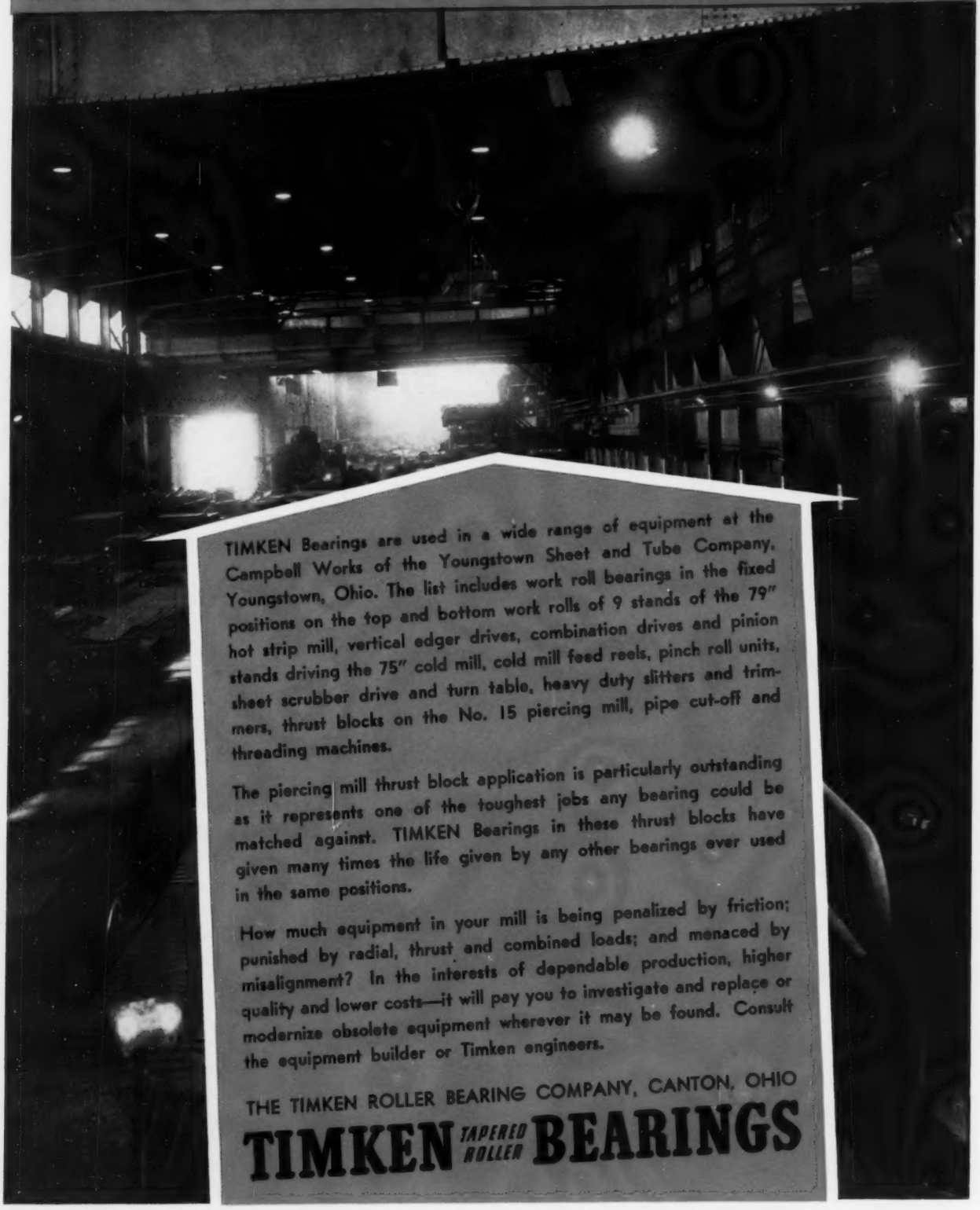
Dependability of steel mill equipment designed and built by Surface Combustion is well-known, and with many years of experience and reputation for highest efficiency of fuel utilization, the lowest-cost-per-ton forecast is easily demonstrated. Call in our Engineers on your "bottle-neck" if it involves the kind of mill equipment we build.

SURFACE COMBUSTION CORPORATION, Toledo, Ohio

SURFACE COMBUSTION

Builders of... ONE WAY FIRED SOAKING PITS, BILLET HEATERS, PACK OR PAIR, ANNEALING, CONTROLLED ATMOSPHERE FURNACES, NORMALIZERS

TIMKEN BEARINGS AT CAMPBELL WORKS
THE YOUNGSTOWN SHEET AND TUBE COMPANY



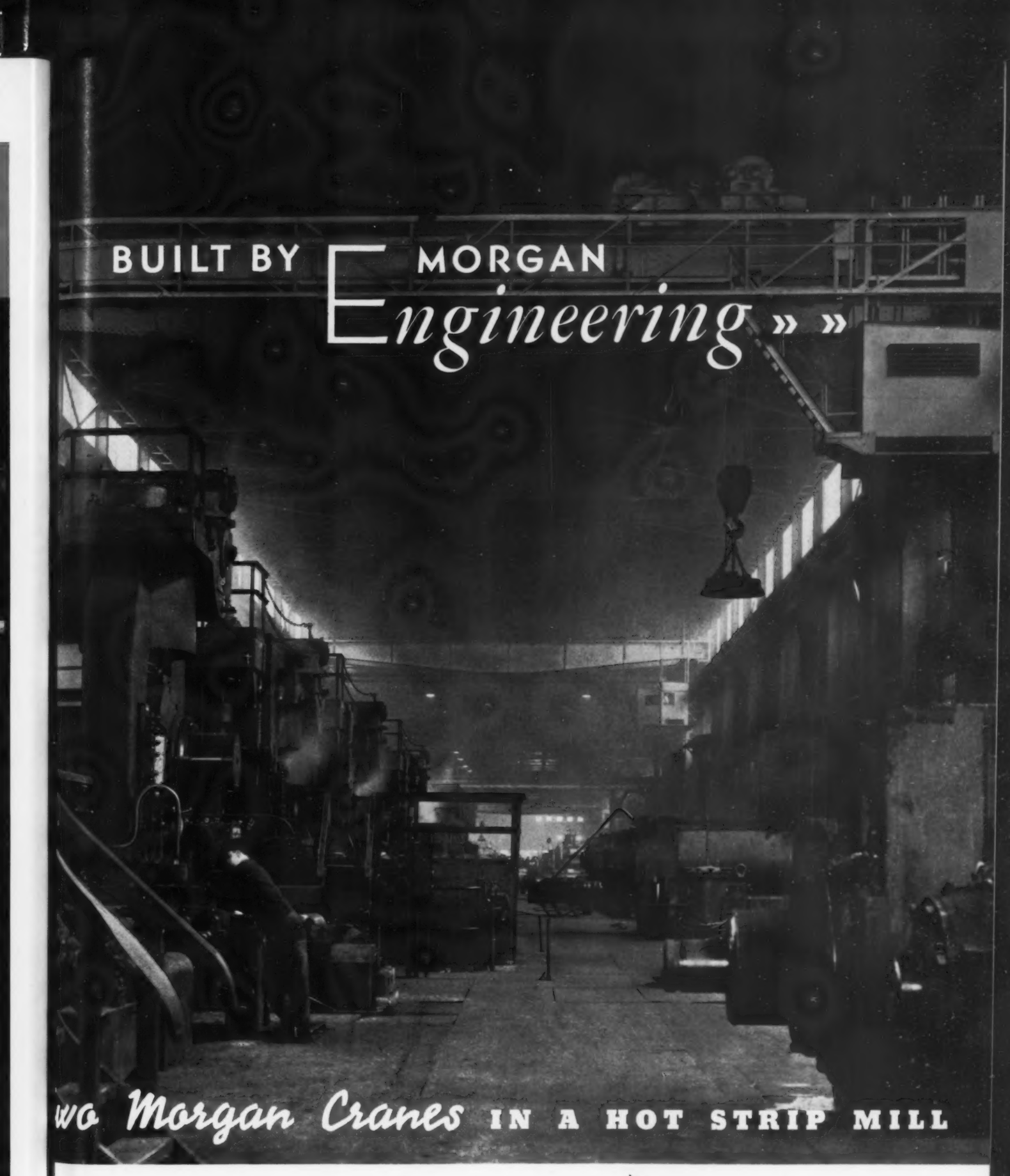
TIMKEN Bearings are used in a wide range of equipment at the Campbell Works of the Youngstown Sheet and Tube Company, Youngstown, Ohio. The list includes work roll bearings in the fixed positions on the top and bottom work rolls of 9 stands of the 79" hot strip mill, vertical edger drives, combination drives and pinion stands driving the 75" cold mill, cold mill feed reels, pinch roll units, sheet scrubber drive and turn table, heavy duty slitters and trimmers, thrust blocks on the No. 15 piercing mill, pipe cut-off and threading machines.

The piercing mill thrust block application is particularly outstanding as it represents one of the toughest jobs any bearing could be matched against. TIMKEN Bearings in these thrust blocks have given many times the life given by any other bearings ever used in the same positions.

How much equipment in your mill is being penalized by friction; punished by radial, thrust and combined loads; and menaced by misalignment? In the interests of dependable production, higher quality and lower costs—it will pay you to investigate and replace or modernize obsolete equipment wherever it may be found. Consult the equipment builder or Timken engineers.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *TAPERED ROLLER* **BEARINGS**



wo Morgan Cranes IN A HOT STRIP MILL

wo 60-ton, 79′8″ span Morgan cranes ing a hot strip mill are shown here, ngsters in service now but because of itional Morgan stamina of design construction, sure to render many s of profitable service. Pioneer build- heavy duty steel mill cranes, Morgan neers are alert to accept the newest, ed advances in crane construction, many of which originate with Morgan. Steel mill capital investment, such as the purchase of cranes represents, is based upon known factors of safety and efficiency—and the Morgan reputation for unswerving integrity. These requirements Morgan Engineering has always met and always will meet, with 55 years of experience as a background.

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★ **DESIGNERS • MANUFACTURERS • CONTRACTORS**

★ BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS
ELECTRIC TRAVELING CRANES • CHARGING MACHINES

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PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

★ **THE MORGAN ENGINEERING CO., Alliance, Ohio**
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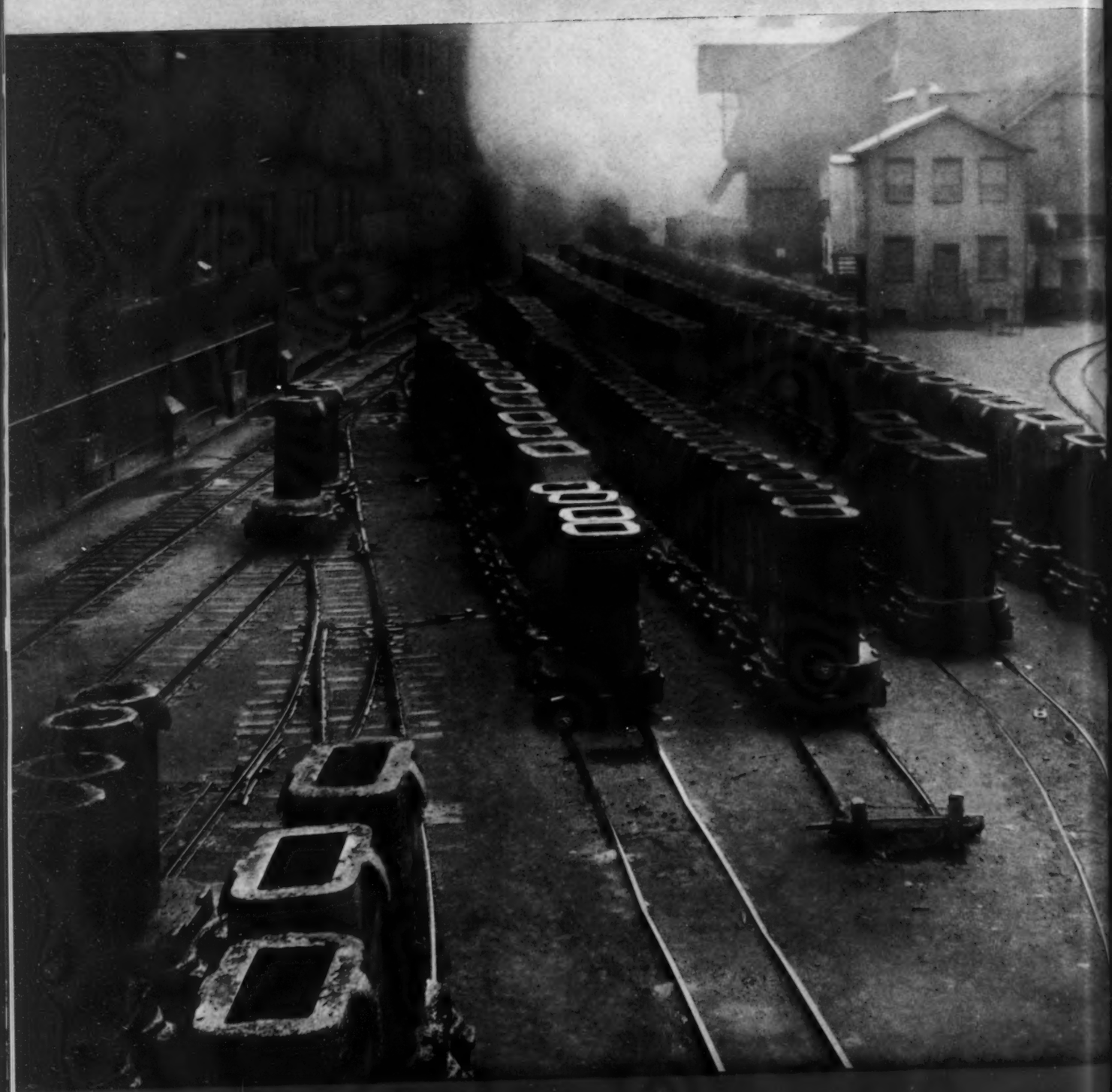
For Half a Century

A LEADER IN INGOT MOULDS



VALLEY MOULD AND IRON CORPORATIO

HUBBARD, OHIO

PLANTS HUBBARD, OHIO — SHARPSVILLE, PA. — CHICAGO, I

TRUMBULL TYPE "A"

Heavy Duty INDUSTRIAL SWITCHES

with the NEW "U" SHAPED

INSULATING CROSS-BAR

This is the switch Trumbull pioneered. For 36 years our Engineers, through research and experiment on Switches of all kinds, have developed better and safer construction methods and material, and kept the Trumbull Type in the van.

Today the Type "A" switch is again improved, as the arrow below points out.

Our Type "A" Heavy Duty switches, particularly adaptable to the requirements of the Iron and Steel Industry, are now equipped with a new insulating cross bar - - "U" shaped to prevent arc-over from accumulation of dust on yoke, and to safeguard against grounding of switch parts in case of excessive overload.

Many of these Trumbull Type "A" Switches are used at the CAMPBELL WORKS of the YOUNGSTOWN SHEET & TUBE CO.

The TRUMBULL ELECTRIC MFG. CO.

PLAINVILLE — CONNECTICUT

A GENERAL ELECTRIC ORGANIZATION

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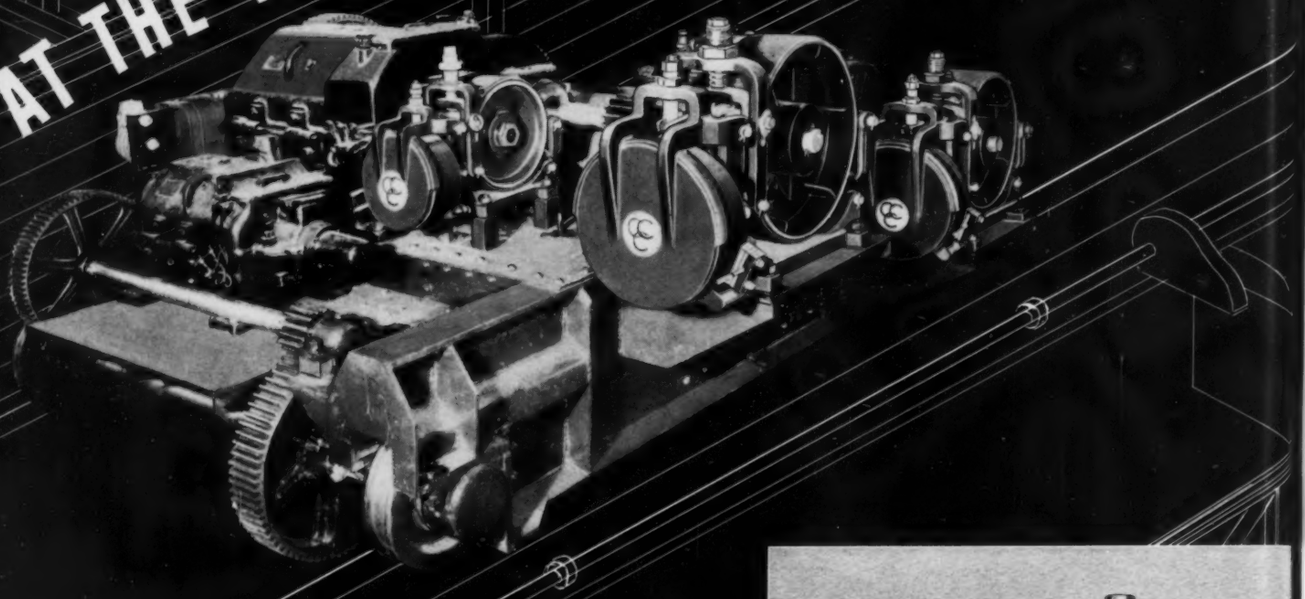
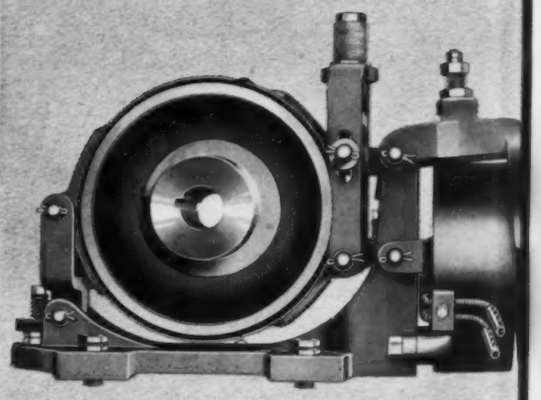
Modern Electric BRAKING
AT THE YOUNGSTOWN CAMPBELL WORKS



A CLEAR PRINCIPLE to start with: the greater the braking surface, the less the pressure per square inch. Logical design that spreads the braking torque over 90% of the wheel area... The wheel practically covered by the brake band. Dirt and grit kept from accumulating on top of the wheel and resultant wear avoided... Wear at all pivotal points virtually eliminated. Stress distributed around the wheel circumference... These and like features shown at the right abundantly entitle *Clark Brakes* to the name of modern.



● Noteworthy features of Clark Brakes are: renewable Nitralloy bushings and harden steel pins at every point of relative rotation minimize wear; (2) welding of band shoe band, which distributes the stress; (3) renew able wearing plates of case-hardened ste to withstand vertical motion of outer yok (4) heavy screw type adjustable bushings mounting holes to compensate for any slig misalignment of mounting pads or platfor

THE CLARK CONTROLLER COMPANY

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CROCKER-WHEELER **COUPLINGS**

at Youngstown Sheet & Tube Company

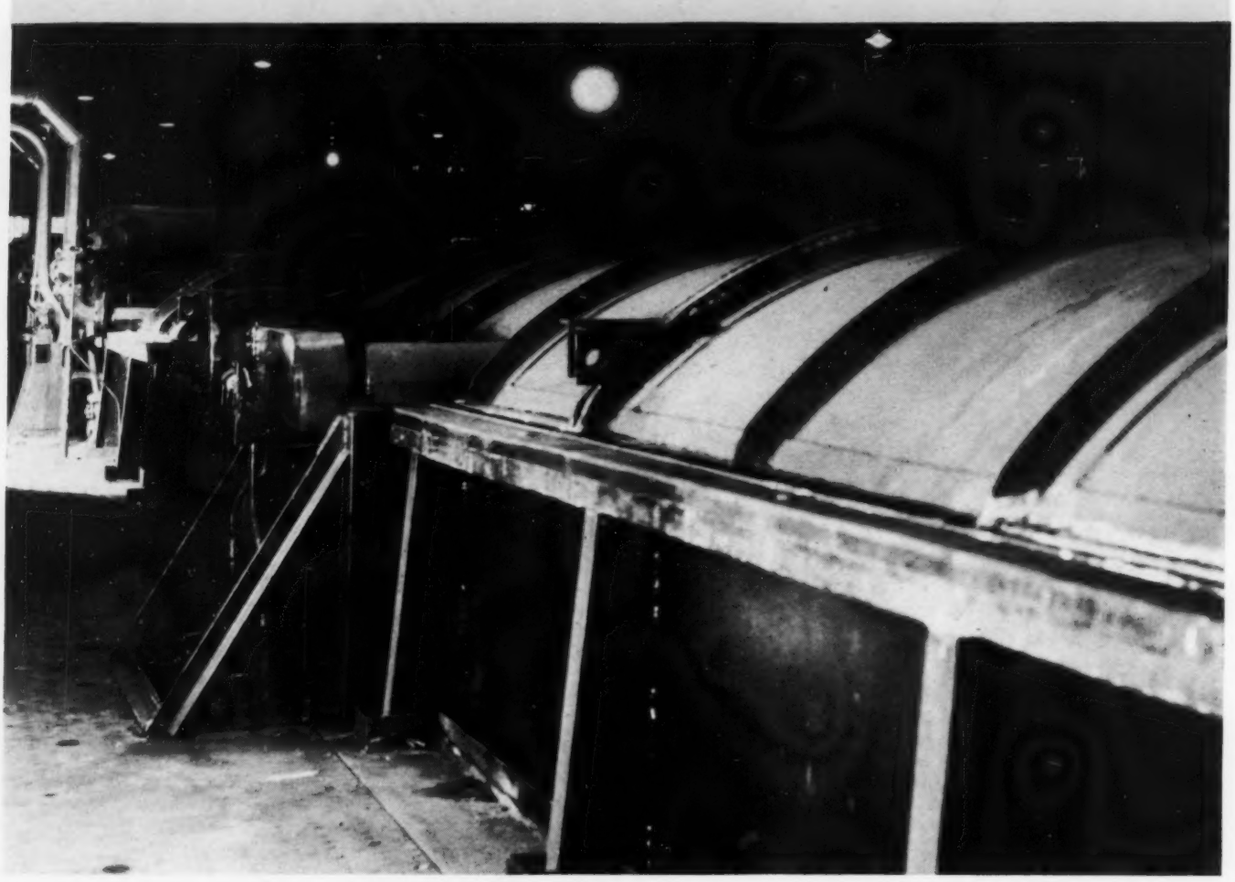
BECAUSE there are hundreds of Crocker-Wheeler, mill-type, resilient, flexible couplings in steel mills; BECAUSE shocks and vibrations are absorbed by the coupling—thus saving other equipment from wear and tear; BECAUSE no lubrication is required; BECAUSE they will successfully withstand high temperatures; IT is natural to find these couplings in use on the cooling bed table rollers of the hot strip mill at Youngstown Sheet and Tube.

CROCKER-WHEELER ELEC. MFG. CO.
Main Office and Works: AMPERE, N. J.
Sales Offices in principal cities

CROCKER-WHEELER

EXCELLENT ENGINEERING

No acid puddles under these modern steel tanks at Youngstown



REMEMBER when a pickling room was a place to avoid? Today it's as neat as any part of the plant—made safe, efficient, more productive by Goodrich Triflex rubber lining.

The photograph above shows part of Youngstown Sheet and Tube Company's modern No. 2 pickle line—four 60-ft. steel acid tanks and two steel water tanks lined with rubber and brick; tank covers, fume ducts, fume and liquid sewer, syphons—all engineered by Goodrich, and all in service for more than a year without a particle of trouble or repair expense.

Shown at the left is the fume and liquid sewer—Goodrich-lined and equipped with an interesting Vulcalock expansion joint you'll want to examine. There is no metal-to-metal contact in this joint. Each flange is bolted to a metal ring imbedded in the rubber. See the rollers below the pipe? Temperature changes cause each 60 ft. pipe length to move about ¼" by expansion and contraction, and this change in length is entirely taken up by the stretch or compression of the rubber joint.

Goodrich tanks and accessory equipment are in use today in 18 continuous wide-strip pickling lines, and are being installed in 8 more. All the wealth of experience, gathered in developing this equipment and engineering its successful application, is at your full disposal. The B. F. Goodrich Company, Mechanical Rubber Goods Div., Akron, Ohio. (In Canada: Canadian Goodrich Company, Ltd., Kitchener, Ontario.)

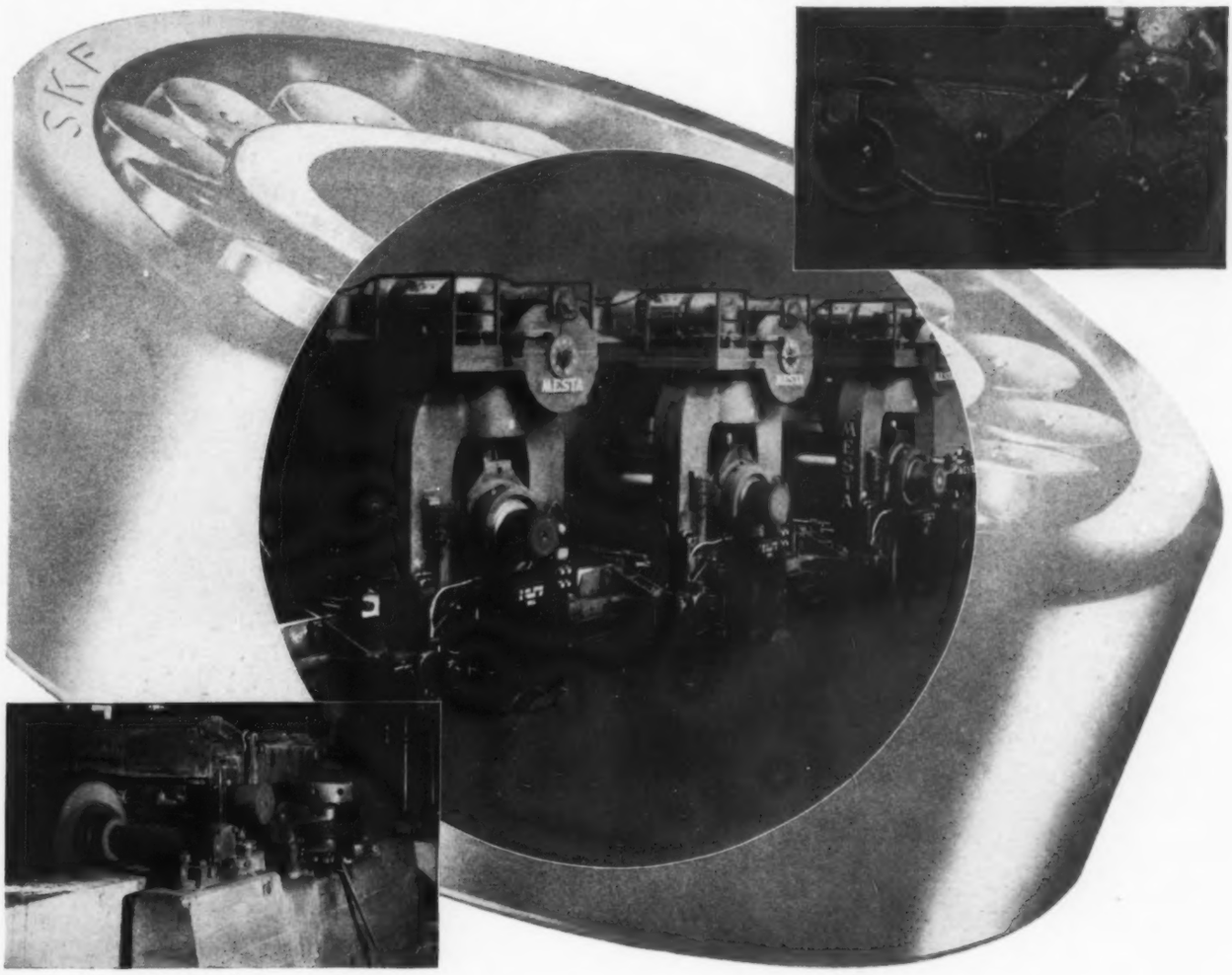
Goodrich

ALL *products problems* IN RUBBER

When you inspect The Youngstown Sheet & Tube Co.

Remember SKF

are on cranes, rolling mills, pickling tanks and motors



Steel mill operators who solve their anti-friction problems with SKF are certain of lower bearing costs per ton. The equalized load distribution inherent in SKF Roller Bearings assures full capacity and long life. Write for catalog, "SKF Rolling Mill Data for Calculation and Design."

SKF Industries, Inc., Front Street & Erie Avenue, Philadelphia, Pa.

SKF

Roller Bearings

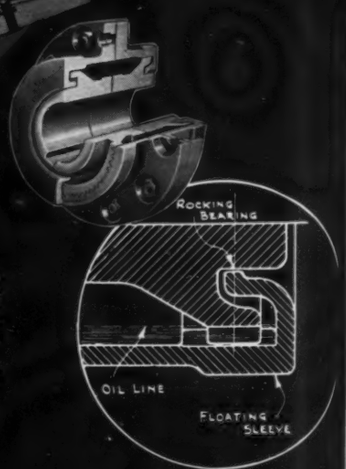
3795

15 YEARS

Of TROUBLE-FREE PERFORMANCE at the Campbell Works

Motor room. New strip mill of the Youngstown Sheet and Tube Company.

That is why Fast's Couplings are used on this new mill.



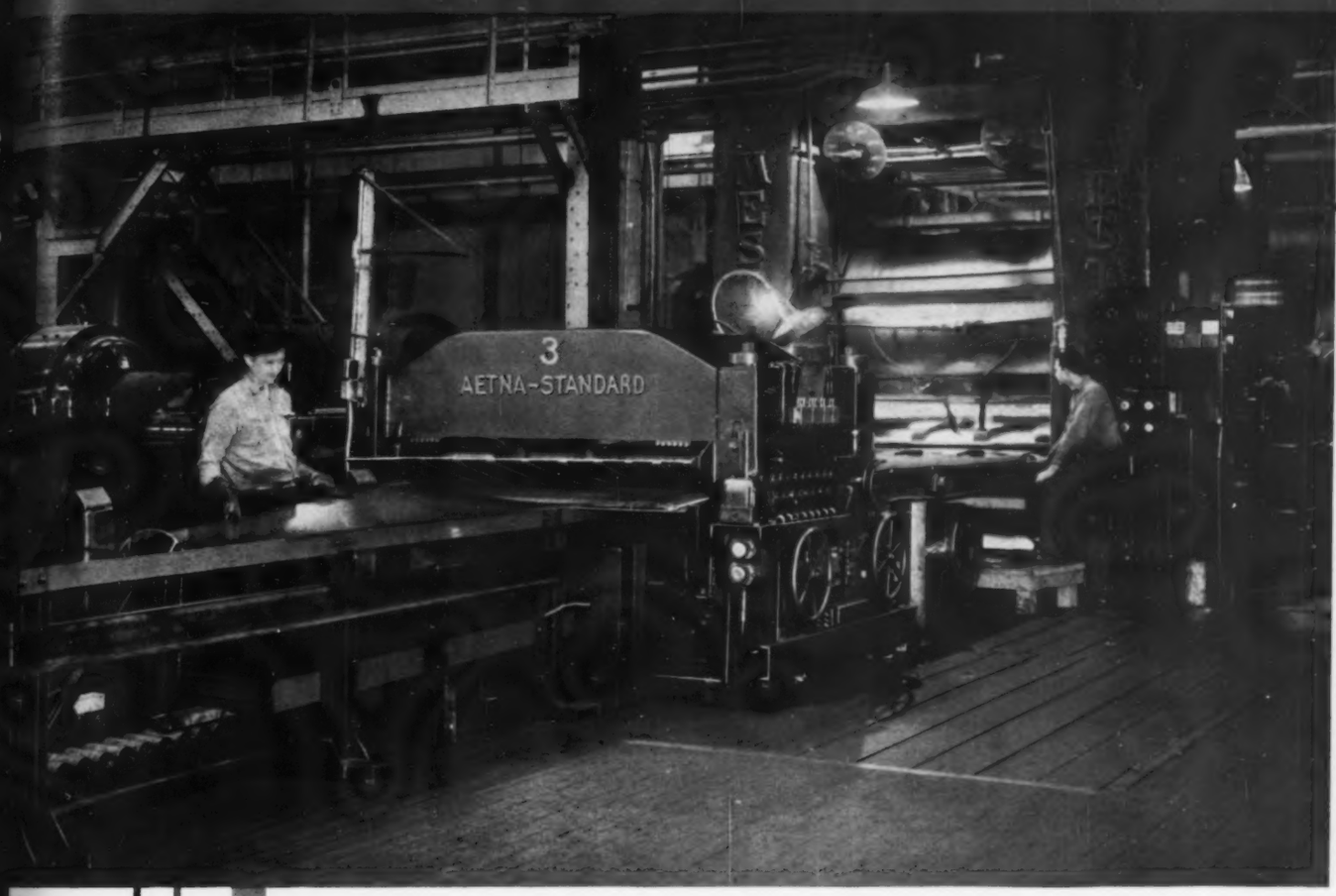
ILLUSTRATIONS that show Fast's construction. Notice, in the detail drawing, that no perishable materials are used to make them dust and moisture proof.

FAST'S PATENTS COVER THESE VITAL FEATURES

YOU, too, can get the same trouble-free performance by specifying genuine Fast's Self-Aligning Couplings on the machinery you purchase.

FAST'S COUPLINGS

"CHATTERMARKS"
NO LONGER A PROBLEM



Five BACKED-UP ROLLER LEVELLERS designed and built by THE AETNA-STANDARD ENGINEERING COMPANY for use in the Cold Strip Sheet Mill of The Youngstown Sheet and Tube Company, have conclusively proven that wide strip sheets can be precision levelled at high speeds WITHOUT CHATTER.

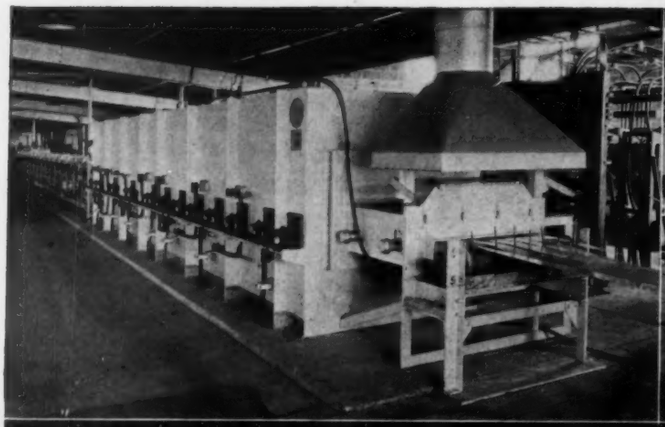
More than forty Aetna-Standard Backed-Up Levellers are in successful operation in the steel and automobile industries . . Consult our Sales Engineers for further information on this subject.

AETNA-STANDARD ENGINEERING COMPANY

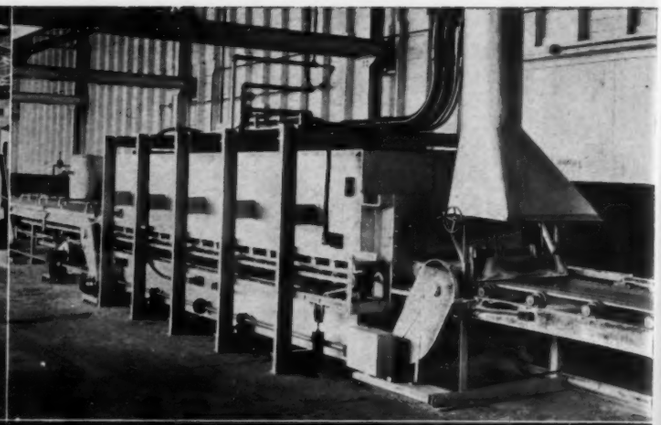
CONSULTANTS · DESIGNERS · BUILDERS

STEEL AND NONFERROUS INDUSTRIES

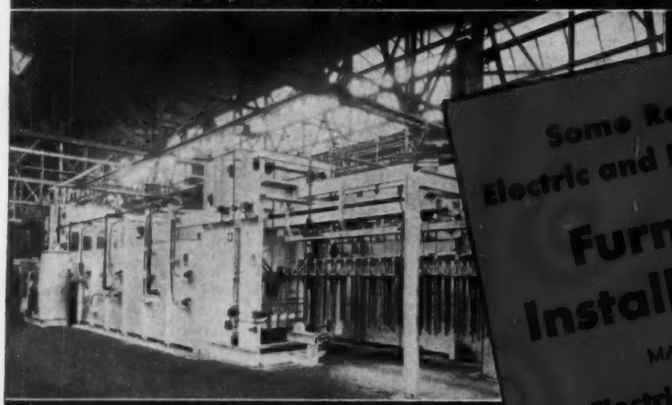
YOUNGSTOWN · OHIO · U. S. A.



Special atmosphere continuous furnace, bright annealing cold rolled steel in strip form—uniformly and economically.



Continuous, special atmosphere furnace bright annealing steel tubing. Any diameter or length successfully handled in this type furnace.



Completely automatic heating, quenching and drawing equipment for scale-free heat treating automobile axles.

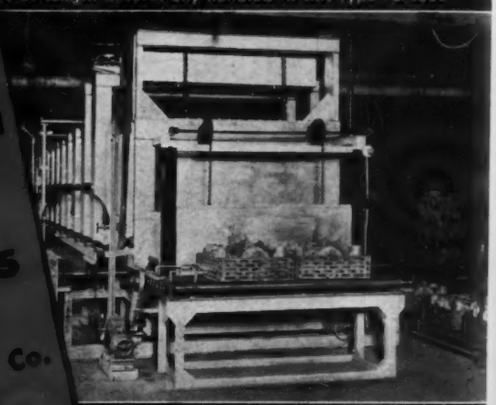
Some Recent Electric and Fuel-Fired

Furnace Installations

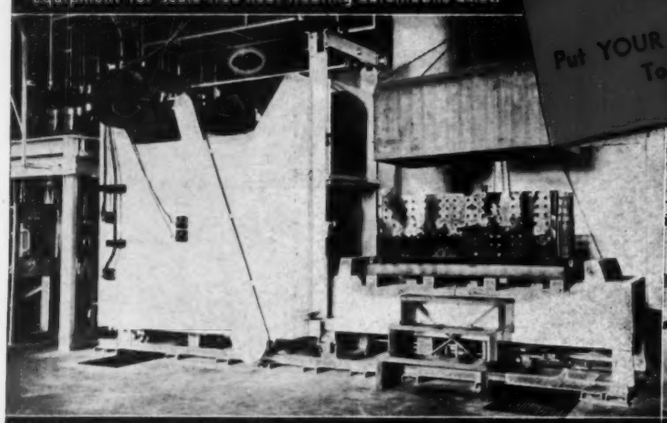
MADE BY

The Electric Furnace Co.
SALEM, OHIO

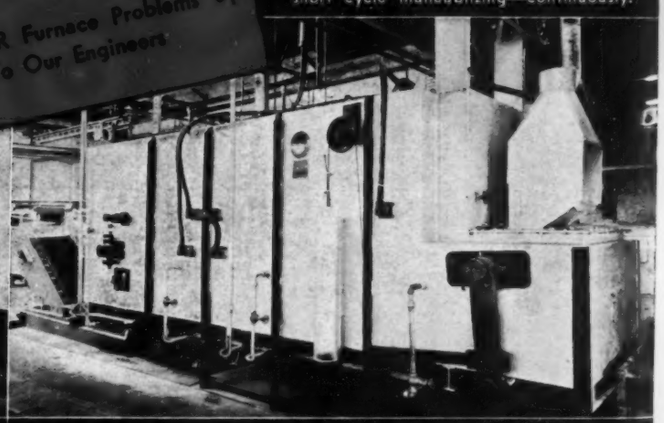
Put YOUR Furnace Problems Up To Our Engineers



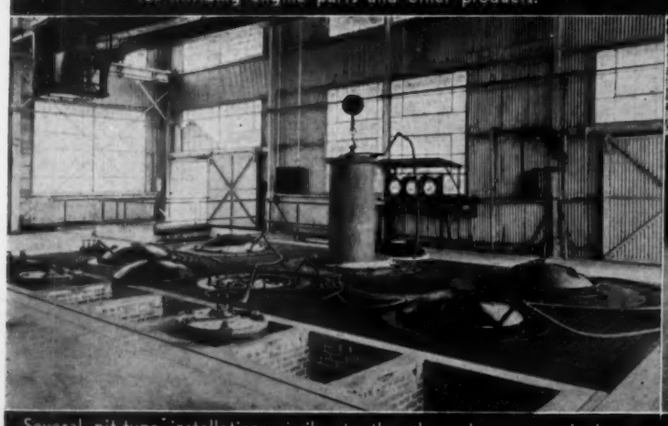
Special atmosphere furnace for scale-free, short cycle malleablizing—continuously.



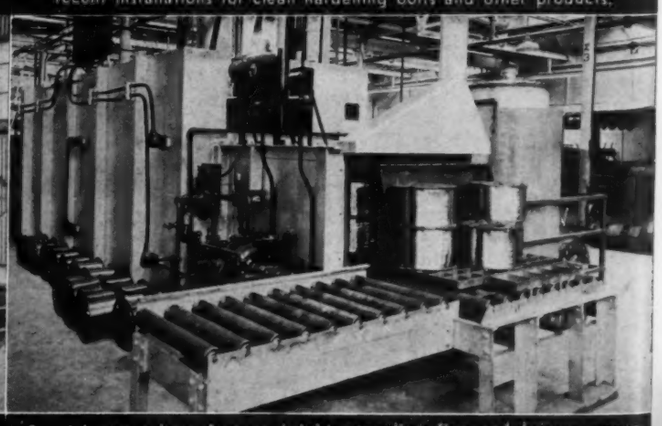
Semi-continuous nitriding furnace—one of several recent installations for nitriding engine parts and other products.



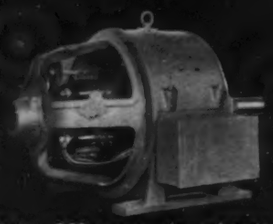
Chain belt conveyor furnace with special atmosphere. One of several recent installations for clean hardening bolts and other products.



Several pit-type installations similar to the above have recently been made for bright annealing wire and normalizing rod.

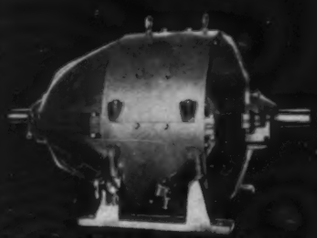


Special atmosphere furnace bright annealing fine and heavy copper wire on spools, reels and in coils—continuously.

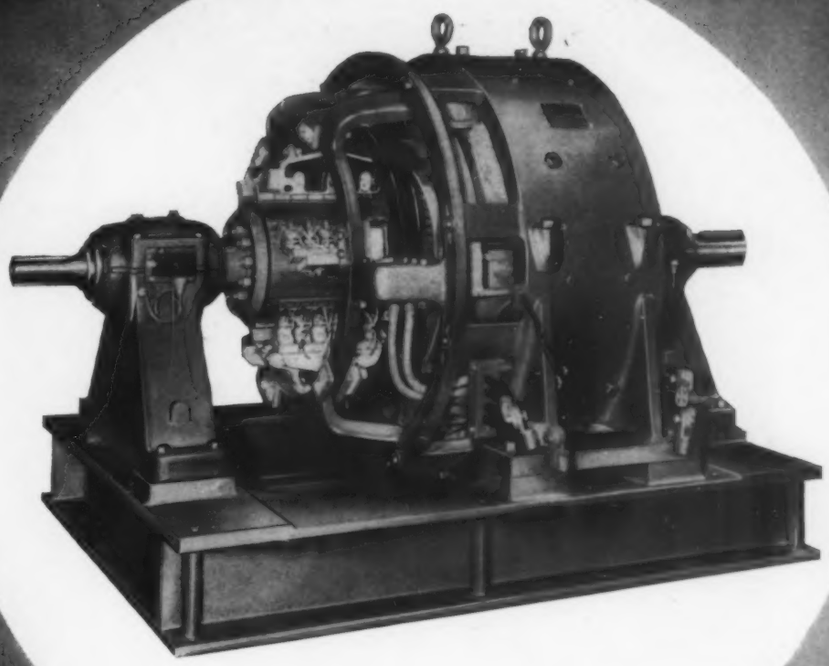


150 hp. 850 r. p. m. sleeve-bearing motor with screen covers over top openings.

75 hp. 400-1200 r. p. m. adjustable-speed, Heavy-duty Type "T" Motor with ball bearings.



350 hp. 850 r. p. m. sleeve-bearing motor with solid covers over the top openings, perforated covers over the lower portion.



500 hp. 500 r. p. m. 6-pole pedestal-type Heavy-duty Type "T" Reliance Motor for direct current.

A *New* MOTOR DESIGNER THAT MADE GOOD!

A composite engineer, if you please, embodying the experience of 35 men responsible for motor operation and maintenance, counselled with us in designing our first Type "T" Heavy-duty Motors 23 years ago. Since then, just such experienced men have at our request contributed materially to Type "T" motor development. Always the call has been for the most thorough sort of insulation; for plenty of good materials in vital spots; for strength, even *extra* strength throughout. These and other features are convincingly present in Reliance Type "T" Heavy-duty Motors. The applications at the right are typical of those you will see in the Youngstown Sheet & Tube Company mills.

THE RELIANCE ELECTRIC & ENGINEERING COMPANY
1088 IVANHOE ROAD **CLEVELAND, OHIO**

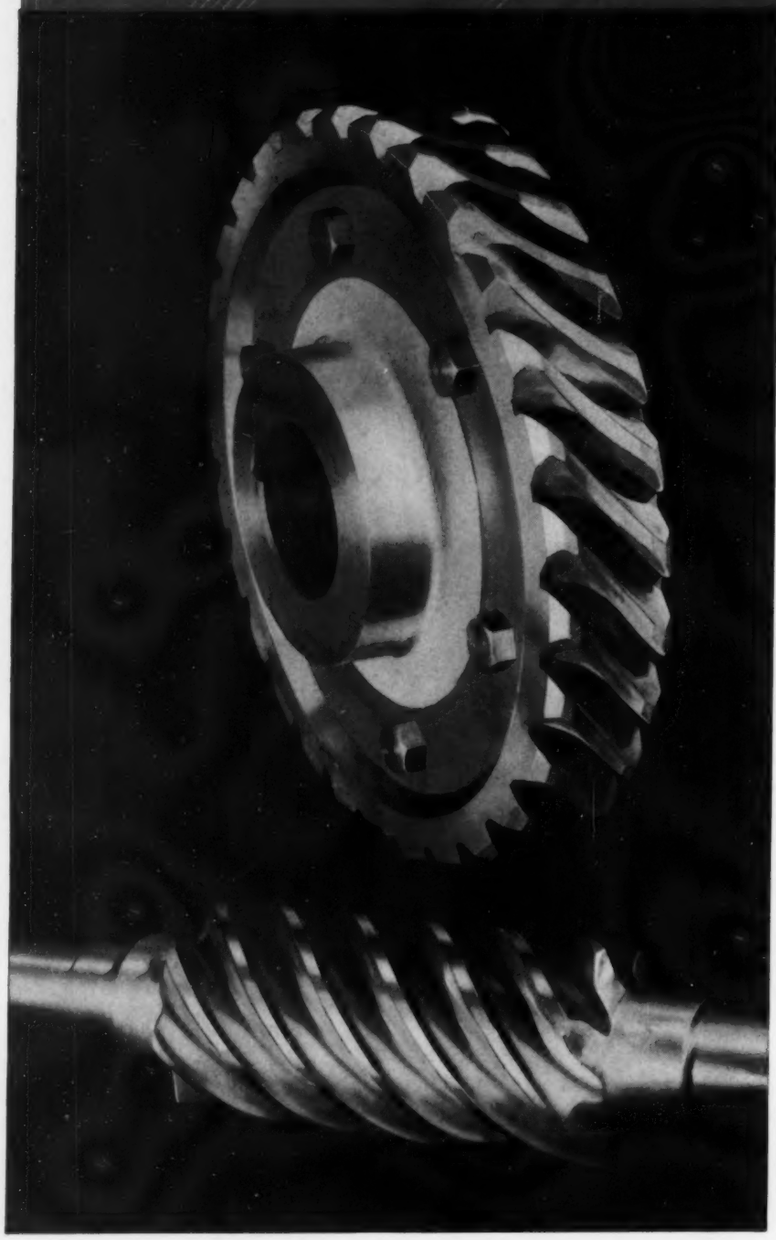
Branches: Boston, Buffalo, Chicago, Cincinnati, Detroit, Greenville (S. C.), New York, Philadelphia, Pittsburgh ***Representatives in other principal cities***

RELIANCE A-C D-C MOTORS

Type "T" Motors driving trimmer and leveller in Cold Strip Mill of Youngstown Sheet & Tube Company.

Trimmer and flying shear in the Youngstown Mill with ball-bearing Type "T" Reliance Motors.

A Standby in the Steel Industry



● In the past 15 years, The Youngstown Sheet & Tube Company has purchased 69 separate applications of Cleveland Worm Gear Drives. The total number of individual Cleveland Units installed is of course much larger than that.

Throughout its 25 years, The Cleveland Worm & Gear Company has concentrated on the manufacture of Worm Gear Speed Reducers. In steel and in every industry where fast, continuous production is imperative, "Clevelands" have long enjoyed confidence and preference through their ability to transmit power quietly, in the proper volume, throughout the lives of the machines themselves —requiring in turn little or nothing more than an occasional oiling.

To help meet some of your own power-transmission problems, a "Cleveland" District Engineer located near you will gladly bring his long training and experience into a meeting with your own Engineers at your convenience. The Cleveland Worm & Gear Company, 3278 East 80th Street, Cleveland, Ohio.

Affiliate: The Farval Corporation, Cleveland, Manufacturers of Centralized Systems of Lubrication.

★ CLEVELAND *Worm Gear Drives*

ROCKBESTOS *Stands Up*

AT THE YOUNGSTOWN SHEET and TUBE COMPANY

Partial view of slab furnaces supplying hot strip mill at the Campbell Works of the Youngstown Sheet and Tube Company. A tough place for wire? Sure, but not for Rockbestos.

SLAB furnaces are hot! No ordinary insulated wire could be run near them and stand up. That is why thousands of feet of Rockbestos wires and cable are used by the Youngstown Sheet and Tube Company, for only Rockbestos can withstand such conditions permanently.

Ordinary wires fail when subjected to continuous heat because the insulation dries out, becomes so brittle that vibration causes it to crack and fall away. But Rockbestos insulation which is basically dense, impregnated, felted asbestos, supplemented by a high dielectric insert—with a tough outer asbestos braid, will last indefinitely. Is it any wonder that Rockbestos wire has a long life before it when ordinary wires have deteriorated to the point of failure?

There are over fifty different types of Rockbestos heat resisting wires, cables and cords. Each is designed for a specific severe service condition. May we send you samples or discuss your wiring problems with you?

ROCKBESTOS PRODUCTS CORP.
840 Nicoll Street
New Haven, Connecticut

Also refer to Electrical World Buyer's Reference Number, December 19, 1936, Part II

A.V.C. Motor Lead and Apparatus Cable
Recommended for constant high temperatures and for ordinary conduit moisture conditions.
A.V.C. Motor Lead Cable
Will not bloom, rot or swell when in contact with oil or grease and will not burn. Remains permanently flexible.

ROCKBESTOS A.V.C.

the wire with permanent insulation

BIG LOADS—

and a TRANSPORTATION SYSTEM *just as Big*

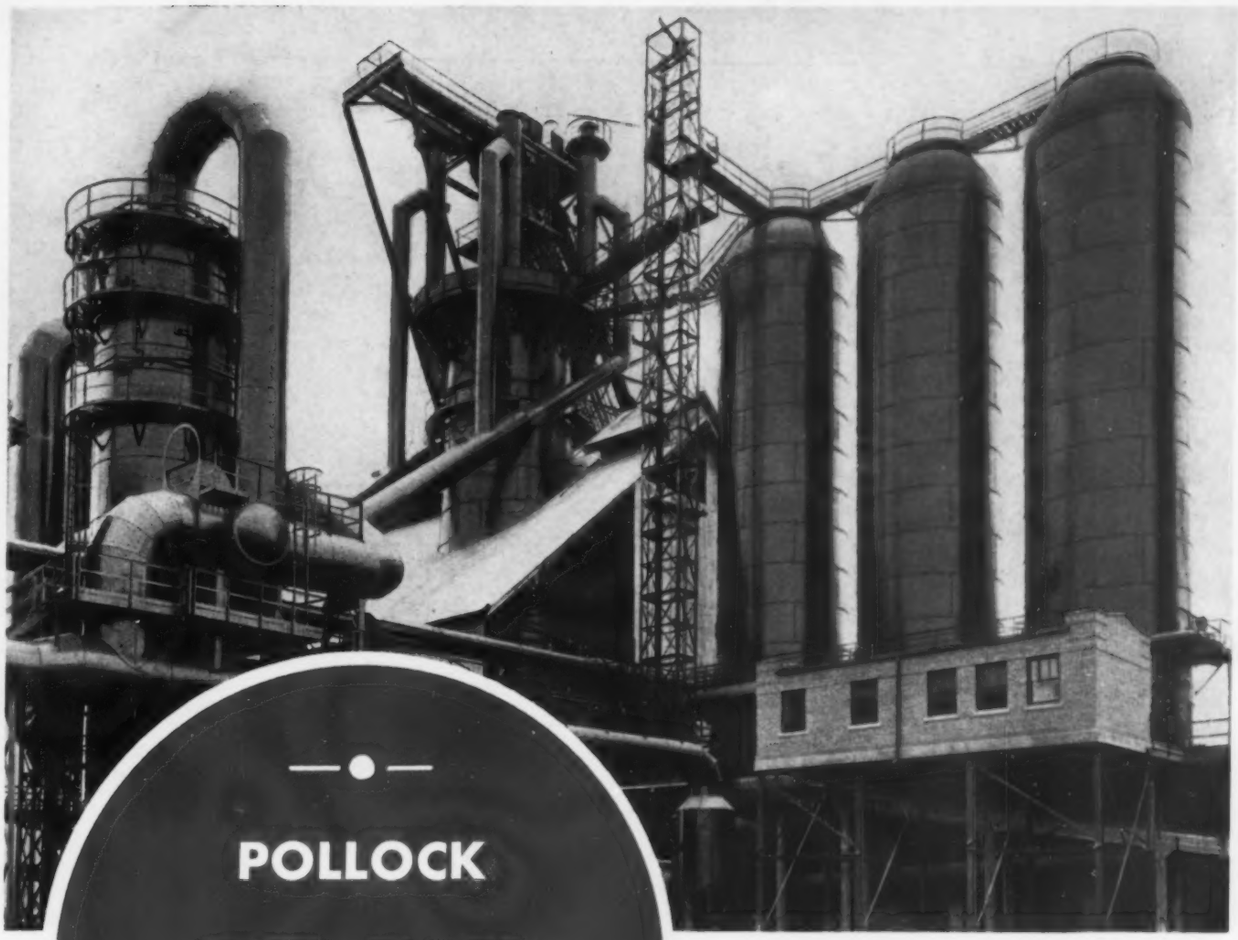
THIS massive Elwell-Parker Electric Ram Truck is one of five used in the new cold strip mill of the Campbell Works of The Youngstown Sheet & Tube Company in handling hot rolled strip. One truck transports coils from continuous pickling unit to the cold rolling stands or stock storage. Another delivers cold rolled strip from the last finishing stand to weighing scales, thence to stock pile. Still another Elwell-Parker transports coils from storage pile to rotary shears.

Each Truck handles 500 to 800 tons per shift. The Company has co-ordinated the travel of Trucks with the movement of steel so that the required heavy volume shall be kept flowing steadily. *Dependable Elwell-Parkers maintain the pace set by pickler, mills and shears.*

In addition to Ram Trucks suitable for transporting coils in standard widths and diameters, Elwell-Parker Engineers have pioneered in developing other Trucks capable of handling steel plant and other loads with comparable speed and facility. Upon request, we will send a Representative especially trained in steel plant problems, to discuss with your own Staff the applications of standard type Elwell-Parker Trucks, or special attachments needed for your particular work. Elwell-Parker, 4504 St. Clair Avenue, Cleveland, Ohio.

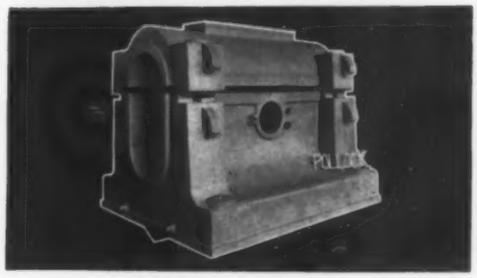
New Type **ELWELL·PARKER** *Trucks*

ESTABLISHED 1893 • BUILDING POWER INDUSTRIAL TRUCKS SINCE 1906



POLLOCK STEEL PLATE CONSTRUCTION

Blast Furnace Gas Seal Hood

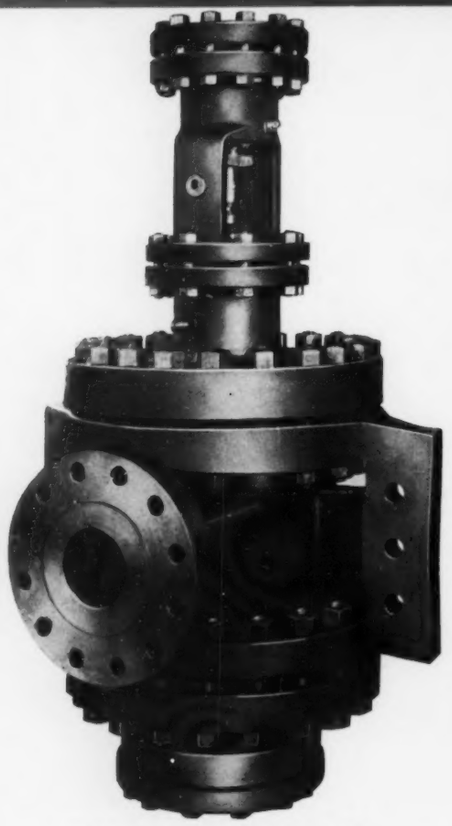


Strip Mill Pinion Stand

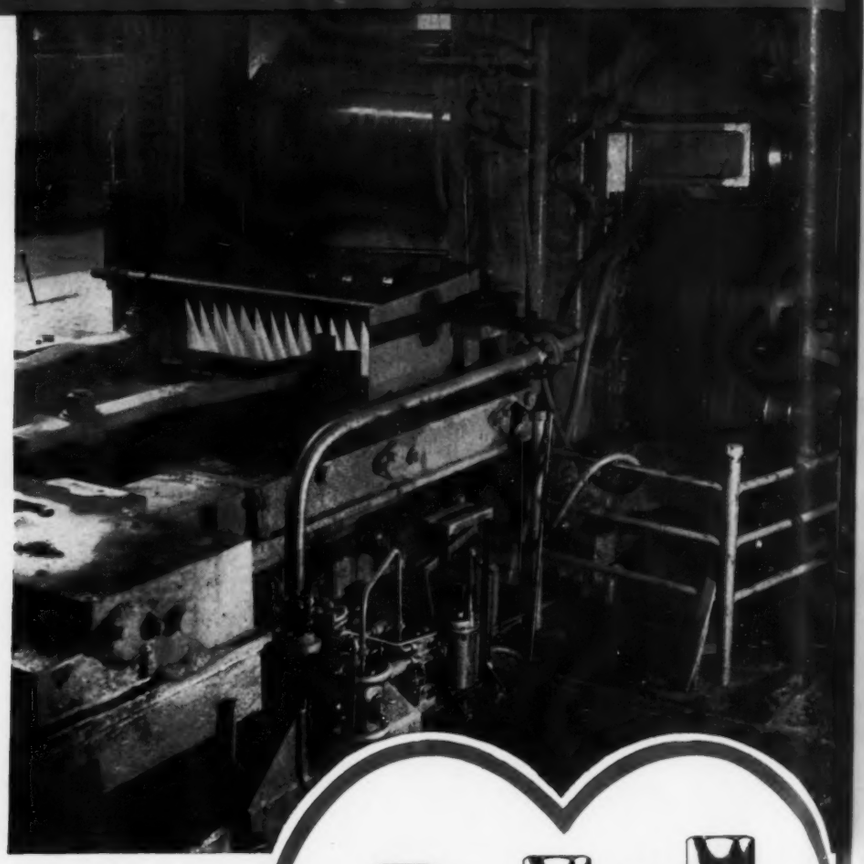
For three-quarters of a century, The William B. Pollock Company has been proud of its ability to meet the diversified requirements of major industries. Complete facilities for engineering, fabricating and erecting steel plate work from the lightest gauge to the greatest thickness is demonstrated by their products.

The William B. Pollock Company
Youngstown, Ohio

HOMESTEAD PROTECTED SEAT SPRAY VALVES IN YOUNGSTOWN'S 79" HOT STRIP MILL



6" Homestead Protected Seat Spray Valve



Nearly two years of continuous operation, with only a few cents maintenance—that is the record of seven 3" Homestead Protected Seat Spray Valves with thrustor operated hydraulic pilots, controlling high pressure hydraulic spray on descaling systems in Youngstown Sheet and Tube Company's 79" Hot Strip Mill.

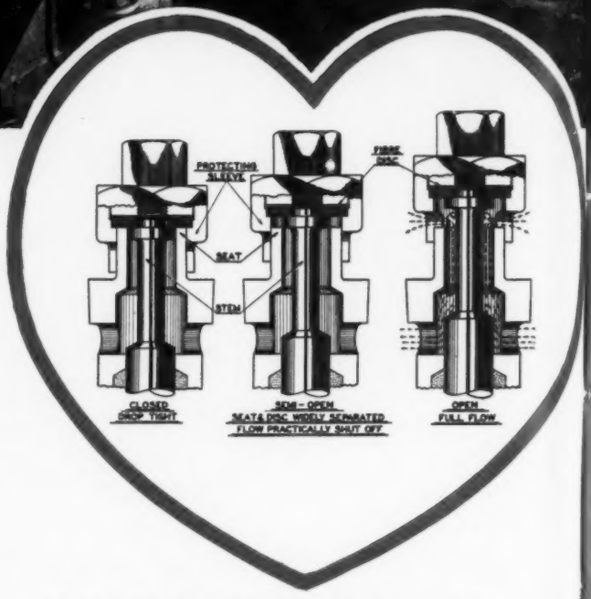
Long, continuous service records with minimum maintenance, such as this, usually result when Homestead Protected Seat Hydraulic Spray Valves, with patented shock control, are on the job. They are the ONLY valves that give you ALL of these profit-guarding features:

1. Protected Seat (B. & O. Patents).
2. Positive, Patented Shock Control.
3. Extremely Low Pressure Drop.

Hydraulic by-pass equipment to prefill spray manifold, is optional, at no extra charge. Types of spray valve control include direct hand operated, direct electric thrustor operated, air operated, remote control with hand, electric, or air operated pilot; and sizes range from ½" to 6" inclusive.

Use Homestead Two-way Protected Seat Hydraulic Operating Valves for descaling steel, or for centrifugal pump by-pass; Three-way and Four-way Protected Seat Operating Valves for controlling manipulators, presses, shears, belling machines, billet pushers, strippers, loopers, etc. And remember, no installation of Homestead Operating Valves is complete without Homestead Lift-Plug Hydraulic Stop Valves on the job.

Send for complete Reference Book No. 37 showing these and other Homestead products. Address request to P. O. Box 30.



Working Principle of HOMESTEAD Protected Seat (B. & O. Pats.)

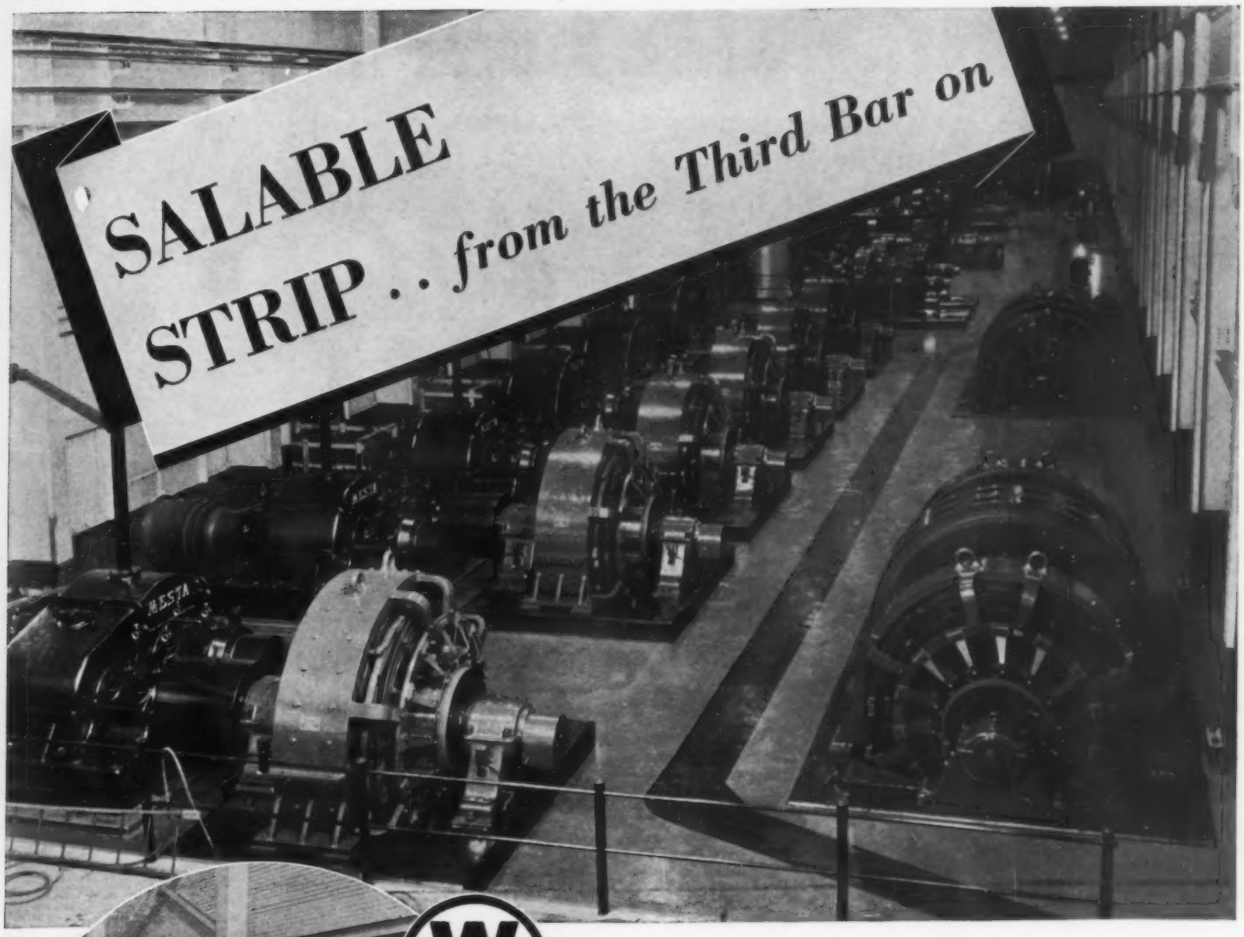
The heart of all HOMESTEAD Protected Seat Spray Valves and Hydraulic Operating Valves is the Patented Protected Seat—unequaled for performance. Notice from the heart diagram, that the seat and disc make contact with practically no water flowing; hence no wire drawing or cutting of the seating elements. That is why you get more positive control, longer, continuous service, and lower maintenance when you use HOMESTEAD Protected Seat Hydraulic Operating Valves.

HOMESTEAD VALVE MFG. CO., Coraopolis, Pa. (Pittsburgh, District)

HOMESTEAD VALVES

QUARTER TURN VALVES:
STRAIGHT WAY
THREE WAY
FOUR WAY
LUBRICATED TYPE
ROUND OPENING REFINERY

PROTECTED SEAT VALVES:
HYDRAULIC (B. & O. PAT.) OPERATING
REMOTE CONTROL
ROSS AIR SHUT-OFF VALVE
HOVALCO BLOW-OFF VALVE



Above—79" continuous strip mill motor room showing the six-3500 horsepower Westinghouse d-c. motors driving the finishing stands. Of the latest type of welded steel construction, these motors are noted for their excellent commutation and reliable operation under all conditions.

In Circle—One of the two-6000-kw. three unit Westinghouse synchronous motor generators that supply 600-volt direct current to the six finishing stand motors. These generators have a slightly dropping voltage-load characteristic that always assures equal division of the load.

★ ★ ★ ***Without a hitch, Youngstown's new 79" Continuous Hot Strip Mill equipped with Westinghouse Motors and Control started to produce marketable coils and hot bed lengths.***

The first day Youngstown's new continuous hot strip mill was rolling salable strip like a veteran.

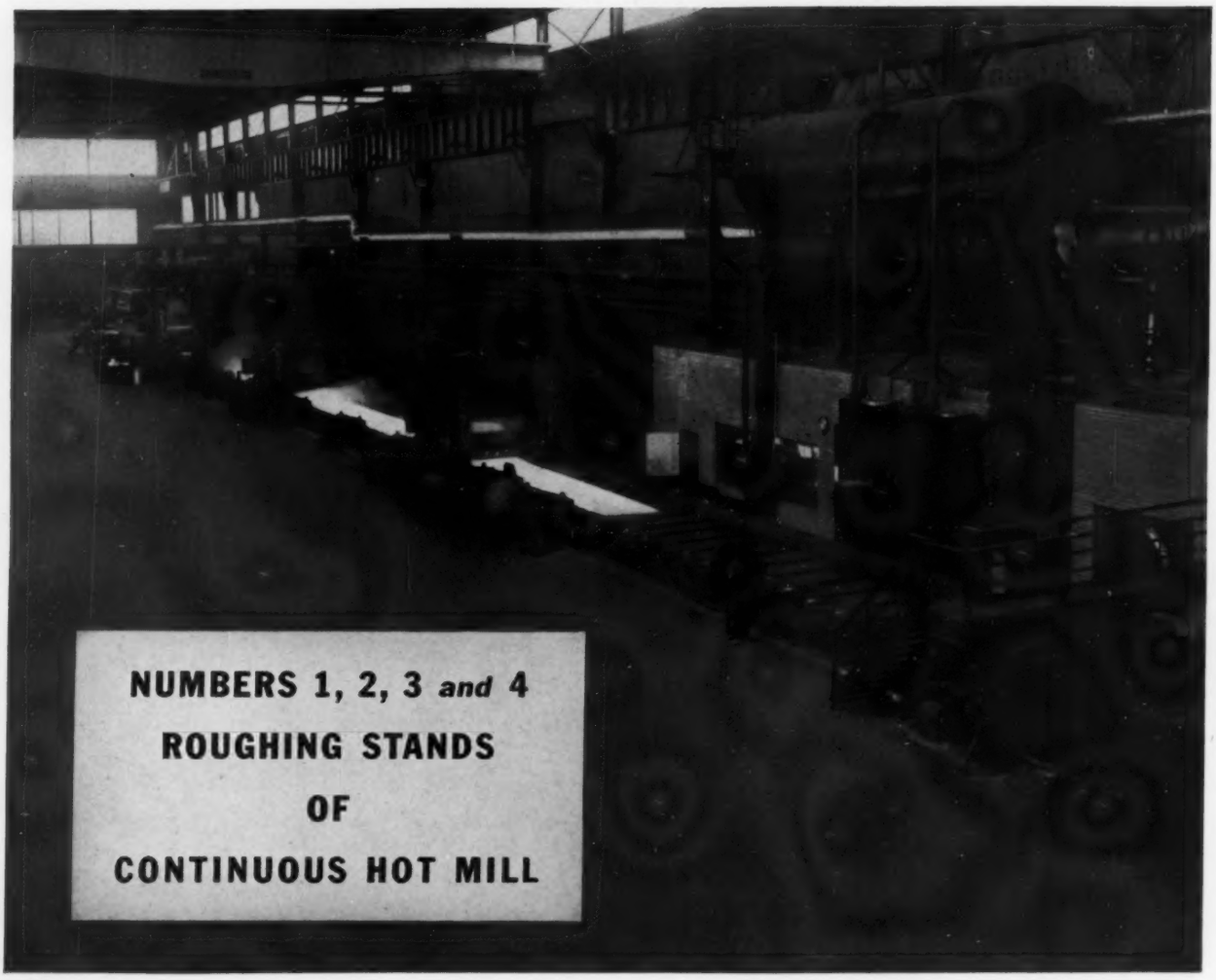
This is a striking example of close cooperation between mill builder and electrical manufacturer—evidence that Westinghouse continuous mill motors and their control are engineered and built to operate successfully right from the start.

Westinghouse engineers, with their broad and practical experience, can select motors with the necessary refinements of control that assure the most economical operation of any type of mill. For additional information, call or write the nearest Westinghouse office.

A 52077

Westinghouse MOTORS AND CONTROL

THE YOUNGSTOWN SHEET & TUBE CO.



CONTROL CABLES AT THE CAMPBELL WORKS

Continuous operation of the electrical equipment of the Youngstown Sheet and Tube Company's new continuous mill at their Campbell Works is assured by the use of our Control Cables. We are proud to be included in this thoroughly modern plant.

THE OKONITE COMPANY

Founded 1878

HAZARD INSULATED WIRE WORKS DIVISION

THE OKONITE-CALLENDER CABLE COMPANY, INC.

EXECUTIVE OFFICE: PASSAIC, N. J.

New York Boston Seattle Buffalo Chicago Dallas Detroit Atlanta
Philadelphia Los Angeles Pittsburgh Washington San Francisco

Factories: Passaic, N. J. Wilkes-Barre, Pa. Paterson, N. J.

OKONITE QUALITY CANNOT BE WRITTEN INTO A SPECIFICATION

A STRIP PICKLE LINE without a McKAY PROCESSING UNCOILER

is like a bird dog without a nose . .

No pickle line is complete without a McKay Processing Uncoiler because it produces strip free from fluting and coil breaks. Material processed by this uncoiler is thoroughly ductile and will not cross break in later forming operations.

Every Wean Strip Pickle Line is equipped with a McKay Processing Uncoiler.

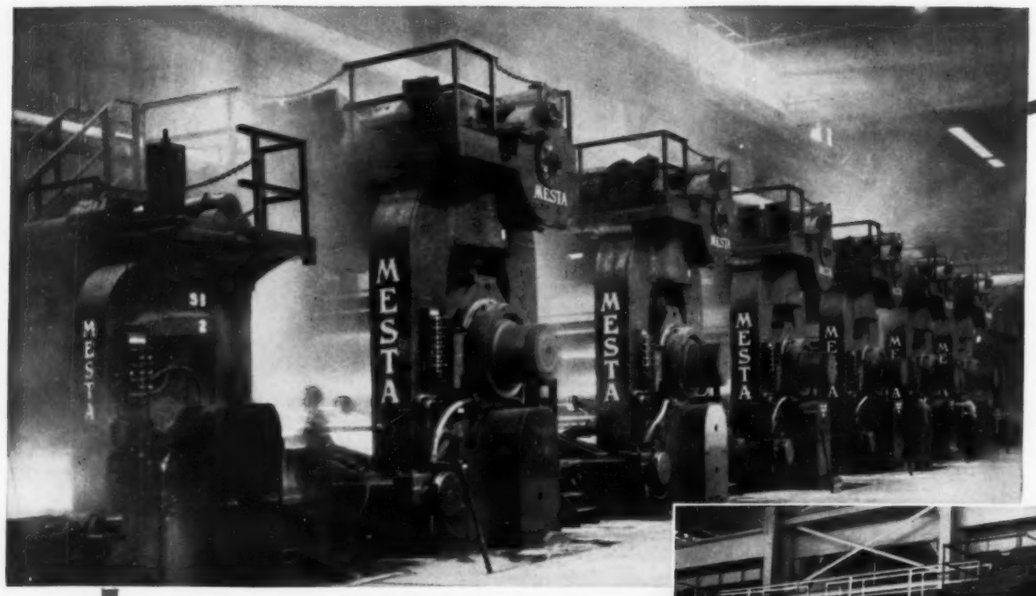
OUR PRODUCTS

UNCOILING UNITS.
PRESS FEEDING EQUIPMENT.
SLITTERS.
STRIP UNCOILING AND AUTOMATIC SHEARING UNITS.
STRIP COIL HOLDERS.
STRIP COILING REELS.
SHEET GALVANIZING EQUIPMENT
AUTOMATIC TINNING EQUIPMENT.
AUTOMATIC DOUBLERS.
NORMALIZING FURNACES.
McKAY LEVELLERS AND PROCESSING UNITS.
CONTINUOUS STRIP PICKLING EQUIPMENT including: UNCOILERS. UP-CUT SHEARS. STITCHING MACHINES. PINCH ROLL UNITS. RECOILERS. DRYING MACHINES. PICKLING TANKS. and AUXILIARY EQUIPMENT.
SCRUBBING. LEVELING. and OILING MACHINES for FLAT PRODUCTS.
WILSON VERTICAL TUBE TYPE ANNEALING FURNACES.
AUTOMATIC FEEDING AND CATCHING TABLES.
CONTINUOUS PACK AND PAIR HEATING FURNACES.
WHEELABRATOR ABRASIVE CLEANING EQUIPMENT.

The WEAN ENGINEERING Company, Inc.
Warren, Ohio

ASSOCIATE COMPANIES

FLINN & DREFFEIN CO. The McKAY MACHINE CO. LEE WILSON ENGINEERING CO.



FARVAL *at the Youngstown Sheet and Tube Company*

● At the Campbell Works, the Farval Centralized System supplies positive lubrication for the new Continuous Strip Mills, consisting of:—

The complete 79" Continuous Hot Strip Mill, Tables and Coilers; also the Tandem Cold Mills, Skin Pass Mills, Shearing Lines, Continuous Pickler, Levelers and other miscellaneous equipment.

With Farval, the quantity of lubricant delivered to each bearing is adjustable, and the frequency may be varied to suit conditions; but the performance is always constant and positive. No bearing receives too much and none is missed.

We will be glad to have a nearby Representative call at your convenience. The Farval Corp., 3278 E. 80th St., Cleveland, O.

Affiliate of The Cleveland Worm and Gear Company, Manufacturers of Automotive and Industrial Worm Gearing

FARVAL

CENTRALIZED SYSTEMS OF LUBRICATION

Automatic Control

IN OPEN HEARTH FURNACES

By A. F. SPITZGLASS, Vice President
Republic Flow Meters Company
CHICAGO, ILLINOIS

Presented before the Annual Convention of the A. I. & S. E., Detroit, Michigan, Sept. 22-25, 1936

▲ THE efficient performance of an open hearth furnace involves a great variety of problems, each of which must be satisfied as far as possible. The actual operations which are under the control of the first helper are relatively few in number, and each one should be well considered with relation to all the elements of the problem affected by it. Fortunately, in an open hearth there is considerable repetition to the cycle of events and it is possible to develop a rather standardized technique *for a given set of conditions.*

During the actual run of the heat, the elements which are at the command of the first helper are (1) the fuel valve, (2) the stack damper, (3) the air inlet and (4) the reversing mechanism.

In this discussion the first three of these items are given primary consideration; but since their effect on the reversal of the furnace is sometimes of major importance the last will also be considered.

In order to see clearly just what must be accomplished by the manipulation of the aforementioned three elements, the main problem must next be stated in terms of the desired results.

The metallurgy and rate of production of the steel are the prime considerations. It is true that fuel economy for its own sake deserves only secondary consideration, but it will be seen later that the assumption that efficient steel production is possible without any regard to fuel economy is questionable. An analysis of the factors governing the problems of production paralled by an analysis of those governing fuel economy sheds some interesting light on this question. They indicate that production and fuel economy are inseparable. The attainment of one automatically secures the other.

Fuel Economy involves, in the main, the proper proportioning and combining of the fuel and air, in order to reduce the sensible heat loss in the exit gases or loss due to unburned fuel to their minimum optimum values. This results in a high flame temperature and the minimum air infiltration; the latter is desirable to prevent cooling of the flame or of the preheated gases.

A. F. SPITZGLASS

Some time ago a statement was published to the effect that the reduction in fuel utilization from six million to four million B.t.u., even though it saved forty cents per ton (upward of $30,000.00 per year for a 150 ton furnace making 600 heats per year) might not be worthwhile if accomplished at the expense of the steel quality or tonnage. The author concurs heartily with this thought, but disagrees entirely with the implication that production or quality are jeoparardized by the correct execution of savings in fuel consumption. To trace the relation between fuel economy and the more important consideration of production, the primary elements of the production problem will be discussed. These are:

1. Maximum output.
2. Maximum length of campaign.
3. Convenient operation of the furnace.

Each of these elements may be broken down again in order to make the comparison. Thus:

1. Maximum output involves:
   - A. Heating the bath as quickly as possible.
   - B. Highest practical flame temperature.

   Adequate heat input and high flame temperature can be obtained only with the cor-

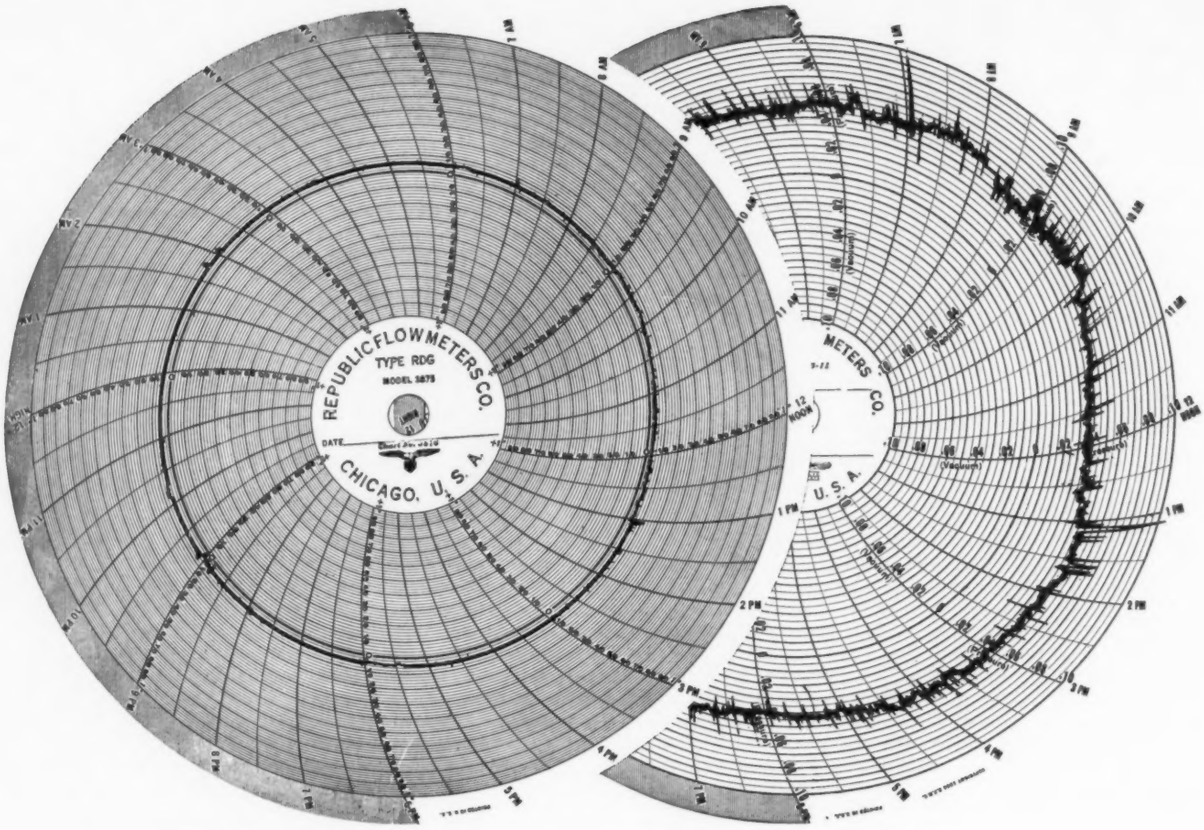


Fig. 1—Effect of Sensitivity.

rect fuel-air ratio; that is, the ratio for complete combustion. A curve of flame temperature vs. air requirement shows a sharp peak at zero excess air, and then drops off rapidly; approximately 150 to 200 degrees F. for every 10 percent of excess or deficiency of air. To secure the correct fuel-air ratio at all times involves the accurate measurement of the fuel and air. The latter is of great importance to insure the duplication of the heat input under similar conditions.

C. Low velocities over the bath.
Heat transfer to the bath takes place mainly by radiation due to the high temperature and luminosity of the flame. High fluid velocities such as are needed where heat transfer is by conduction and convection, as in the checkers, are not required. Low velocities expose the bath to the flame for a longer period of time and, consequently, are vital in securing maximum transfer of heat to the bath. Low velocity, for a given design and a given fuel rate, means *minimum excess air or again proper fuel-air ratio.*

D. Minimum carry-over of the charge.
This requires a low velocity over the bath, and the same considerations apply.

E. Flame direction.
The design of the furnace and ports are, of course, main factors involved here. The effect of furnace pressure on the location and spread of the flame, however, has received considerable attention lately. Many fantastic theories are built up around the concept of furnace pressure and the entire subject is a little too lengthy to discuss here. If we realize that there is practically no difference in pressure between the top and bottom of the furnace, that "heat head" is really due entirely to variation in absolute pressure *outside* of the furnace, we get a truer picture of the actual conditions. It is not the pressure, therefore, but the fact that in a properly controlled furnace a slight infiltration exists near the bottom of the wickets and causes the flame to seek the lower level, where due to the infiltration some excess air supply is available. Thus, in a secondary manner, accurate furnace pressure by regulating these levels does affect flame direction.

F. Atmospheric conditions to assure correct reaction.
Control of the atmosphere over the bath, of course, means the control of the fuel-air ratio. This is necessary to obtain a maximum flame temperature, as indicated above, and also because the nature of the furnace atmosphere exercises a marked effect upon

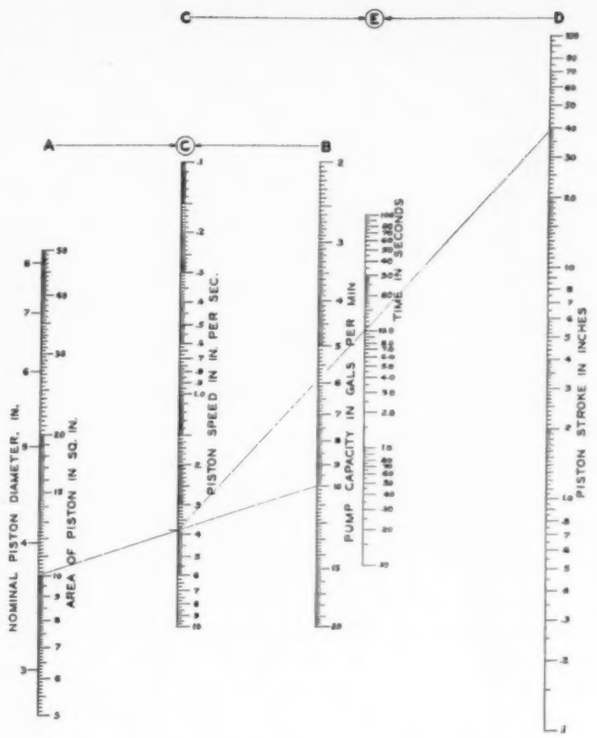


Fig. 2—Speed of liquid operated power cylinders.

the chemical reactions in the furnace. Whenever reference is made to a reducing or an oxidizing atmosphere, it is really fuel-air ratio which is being discussed. It is obvious, therefore, that with measured control the required type of atmosphere can be produced, and any excess of combustion component, in either direction, which may either reduce the flame temperature or the fuel economy can be avoided.

2. *Maximum length of campaign.* Under this heading there also are several parallels between our problem of combustion control and production.
   A. Complete combustion of the fuel.
   Cleanliness and long life of the checkers are a direct result of the reduction of soot and flue dust effected by perfect combustion. As the flow of excess gas is increased, its ability to carry dust and soot increases as the sixth power of the velocity.
   B. Maintaining proper roof temperatures.
   This obtains if the flame is kept down over the bath by proper furnace pressure control. Another important consideration is the determination of the exact combustion rate. This enables the operator to gauge more accurately, from his experience, just how rapid a rate of firing is safe for a given installation. Automatic control of roof temperature is also very important here since it acts as a safety check on the maximum combustion rate.
   C. Keeping air pressures as nearly atmospheric as possible.
   Without control, attempts to keep positive pressures or rather differentials to atmosphere often cause excess pressures; for short periods of time, at least. Flames shooting out through a brick work are a common sight, and, of course, increase furnace maintenance considerably.

3. *Convenient operation of the furnace.*
   The first helper is busied with many things during the progress of the heat, and many of the adjustments embodied in a good combustion control are of invaluable assistance in aiding him to control his operation of the furnace.
   A. Fuel rate should be easily adjusted to the variety of controlled values. On oil firing, hand setting is particularly inaccurate because of the variable temperature and pressure conditions along the piping between the pressure regulators and the burner. Because fuels, where good metering is available, and individual pressure control is applied to each open hearth line, manual setting of the fuel rate can be accomplished practically. However, this is really a substitution of a pressure regulator for the flow regulator, and is merely a short cut to flow regulation. In order to be accurate it involves practically the same apparatus as the flow regulator, and often is more profitably incorporated into the scheme of fuel-air ratio control.
   B. Reversing the furnace with a minimum loss of time and disturbance to the atmospheric conditions. *Upon reversal the pressure in the furnace always changes.* The heat heads at the two ends cannot balance each other exactly and the air infiltration at the two ends varies as well. Likewise, fuel flow changes when the furnace is reversed unless controlled from an actual flow measurement. This is especially important in the case of liquid fuels where temperature and atomizing conditions play such an important part.
   C. Periods of liberation of CO or moisture require ready adjustment of the excess air. This, of course, means adjustment of the fuel-air ratio and is materially assisted by the presence of control equipment.

Thus, we have listed twelve problems of production and paralleled them with twelve operations of fuel economy, and it is obvious that they harmonize completely. Every requisite of production has its counter part in fuel economy. Therefore, not only should the operator go after the forty cents a ton fuel saving where it is available, but, unless he does so, he is not doing everything possible to attain maximum production.

The solution of the basic problems requires the thoughtful application of all the aforementioned factors, as well as intelligent and thoughtful design of the furnace. For many years the open hearth furnace has been notoriously inefficient, especially in regard to its fuel economy. More recently there has been a

general awakening to the importance of improving its design. Automatic design has played a great part in emphasizing the necessity for many of these improvements. In the early stages, the application of control was strictly limited by many inherent defects in the construction of the furnace, and frequently improvements which were suggested to make automatic control of the furnace a possibility, have reacted to benefit the operation in a much broader way.

MISCELLANEOUS MECHANICS OF CONTROL

In addition to the main problems of production and fuel economy, a number of incidental problems arise from the inherent character of the open hearth furnace itself.

(a) Extremely low pressures create a demand for utmost sensitivity of measurement.
(b) Slide dampers, due to their great weight, require operating gear of great power and ruggedness.
(c) Waste heat boilers simplify the control problem somewhat by substitution of a light, fast moving damper for the heavy slide damper.
(d) Producers must be operated to balance the demand created by the open hearth.
(e) Multiple fuels involving mixed gas, oil and gas, with common or divided air supply, are very commonly used and must be totalized for proper combustion.
(f) Special furnaces, such as Isley stacks, require unique reversing gear to make control possible.

If the movement of each of the devices which have to be actuated, (valve, stack damper and inlet air valve) are considered from their relationship to the various divisions of the main problem, it is found that every one of them affects the entire scope of the problem in some way or the other. Every change in the position of the fuel valve, stack damper or the inlet damper, causes some corresponding effect on every one of the production problems, as well as the fuel economy problem. This means that when a man is making a change in any of these settings he is consciously or unconsciously changing some twenty odd functions and it is rather a remote possibility that he can do this accurately day in and day out. An automatic control can take over many of these repetitive operations and eliminate enough of the variables so that the operator is able to apply his own experience as a refinement of the normal control of operation. If a premium is placed on intelligent operation, this will gradually reflect itself in improved metallurgy and greater output, as well as fuel economy.

THE REGULATOR

The mechanism by which these various operations are to be performed requires separate consideration. In the substitution of machine for human operations, it is possible to retain many of the elements of "intelligence" which we assume for the latter. The human operator responds to various degrees of stimulation to a correspondingly varying extent. If he is intelligent his response varies not only in direction, but in degree, in speed, and in acceleration, as required, and unless

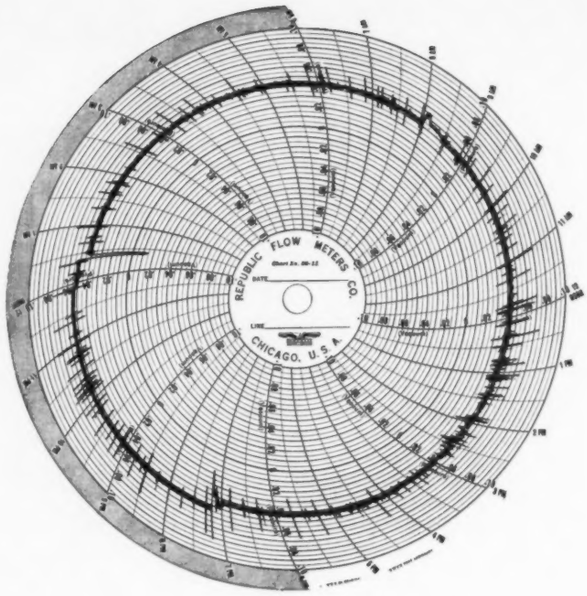


Fig. 3—Open hearth furnace pressure chart.

the machine or regulator is equally "intelligent" its natural advantage of continuity of operation will be wasted.

Not all pieces of mechanism have the required "intelligence" to satisfy the requirements for open hearth control, In order to give accurate, dependable results, there are four essentials: Sensitivity, Speed, Power and Stability. These are relative qualities and they must be present in a good regulator to an excessive degree, or else it cannot function as satisfactorily as the intelligent human operator. One of the great difficulties with early controllers was the fact that these four qualities were contradictory instead of complimental with respect to each other. That is, extreme sensitivity usually meant lack of stability, speed and power. Likewise, stability often had to be obtained at the expense of the other requirements. For open hearth control it is best to build the regulator so that each of the four essentials (sensitivity, speed, power and stability) can be adjusted separately to the specific needs of the installation. The significance of each of these four essentials will be discussed in detail.

Sensitivity: This requires
(a) large operating forces or large diaphragms,
(b) sensitive relay mechanism to prevent reaction or interference with the diaphragm motion,
(c) independent stabilizing method.

Probably the greatest hindrance to a sensitive control lies in the means used for stabilizing it. Frequently a regulator which could be made sensitive, has its sensitivity reduced purposely to prevent it from hunting.

Power. This depends on the size of the operating piston, but is sometimes limited by the character of the relay mechanism. Unless the relay mechanism renders the power cylinder absolutely independent of

the measuring element, then there is bound to be a decrease in sensitivity.

Speed. This likewise involves the other characteristics. *Speed of response* depends on sensitivity and the character of the relay. *The speed of a regulator movement* also depends on its sensitivity, but even more on the stability of the mechanism.

The *maximum speed* at which the regulator can operate depends entirely on the relation of the pump capacity to the size of the power cylinder and Figure 2 is a quick means for determining the size of pump necessary once the cylinder dimensions are known. It is physically impossible for a cylinder to move any faster than shown on this chart and the chart is presented because there is considerable tendency to economize on the size of pumps to the detriment of the operation of the controller. The biggest advantages of the hydraulic system are the speed and power attainable, but these advantages are lost if the pump is too small.

Speed of operation, coupled with power and stability, is more difficult to attain with pneumatic or electric drives than with hydraulic drives. It is obviously impossible to apply power rapidly with air cylinders due to the compressibility and consequent overexpansion of the gases. Air operated devices have their place but not where speed and power are such important considerations.

Electric motor drives have been built which approach the smoothness of power application characteristic of the oil cylinder. These differ tremendously from the commercial electric actuator and are so expensive and complicated as to be of no consequence at the present stage of their development. It is interesting to review a symposium conducted under the auspices of this society five years ago comparing electrical and mechanical devices for combustion control of open hearth furnaces. Five different control manufacturers were represented, three of whom marketed electric drive, one oil and one air. At that time the number of hydraulic operated regulators exceeded all other types. A statement was made by one of the advocates of hydraulic control that it was impossible to obtain an electric equivalent, and the answer was given that one of the large companies had made just such an electric drive, although it was rather elaborate. Since then research has followed, and thyratron technique has been developed to a considerable degree. However, in spite of the fact that the last five years have seen the most intense electrification developments in other directions, the marketable regulators for open hearth control devices remain exactly as they were at that time, hydraulic operated, and the saleable electric motor drive is still the one-speed device. Furthermore, the number of manufacturers offering hydraulic operation has increased and those offering electric operation decreased. Today, hydraulic drives have been made more convenient, and by far the big majority of all combustion and pressure controllers used in the steel plant are of this type.

Stability, in a regulator, refers to its ability to hold or to reach a steady position, after a disturbance, in a reasonably short interval of time.

Undoubtedly, there are some processes which are inherently stable and any stabilizing element built into the regulator may be superfluous. However, since most steel mill processes involve storage and time lag, they are seldom inherently stable and consequently, regulators for controlling them must have independent stabilizers built into them. It is always good engineering practice to design to meet most severe conditions, and nowhere does this fact apply more truly than in the steel mill.

FURNACE PRESSURE—STACK DAMPER

The interior of an open hearth furnace involves a very complex pressure condition due to the high temperatures and to the impingement of the flame upon the bath. The actual furnace pressure varies from point to point all along the hearth and the point selected as a base for measurement, usually near the center of the roof, is important only as an index to the general condition throughout the rest of the furnace.

A positive furnace differential to atmosphere under the roof can be obtained without control, but several factors contribute to make the requirement for accuracy in this matter difficult to maintain by normal manual operation. In the first place, due to the stack effects of the hot gases over the bath, the pressure changes roughly 13/1000 in. water for every foot in height. It is not practical to operate with a positive pressure very much below the top of the wickets, and, therefore, it is necessary to keep a pressure of approximately .04 in. or .05 in. water at the very top of the roof in order that atmospheric pressure shall exist just below the top of the doors. A very slight change in pressure raises or lowers the atmospheric level considerably. Because of these phenomena the measuring element of the regulator should possess high sensitivity

Since a pressure variation of plus or minus .005 in. of water in the furnace roof corresponds to a variation of plus or minus 6 in. in the location of the atmospheric level strata, the controller must respond to deviations considerably less than 0.001 in. Until quite recently many of the open hearths in which control of the furnace pressure was being attempted were equipped with draft gages which were too limited in their sensitivity. These instruments for checking the regulator sensitivity frequently made their records on charts which had too coarse a scale. Consequently the furnace pressure record was practically a single line and fluctuations of .005 in. water were not visible. These apparently fine records obtained with furnace pressure control were responsible for the false conclusions that furnace pressure control did not improve the furnace performance. It was assumed because the records looked so good that the control was functioning satisfactorily and gave all that could be accomplished with furnace pressure control. Figures 1 and 3 illustrate this point. Figure 1 presents two charts on the same line. The one on the left was actually used to check an open hearth furnace pressure control. Its graduation is so coarse that it gives no indication whatsoever concerning the manner in which the control apparatus functioned. The one on the right is taken from a commercial draft gage of high sensitivity. With the latter the slightest change in pressure or movement of the damper is visible on the chart. The two charts represent the same record

but they tell a vastly different story. Figure 3 shows an actual operating record of the furnace pressure obtained with this type of sensitive draft gage, in an open hearth equipped with furnace pressure control. The use of more sensitive draft gages has contributed largely to making it possible to study furnace pressure conditions more intelligently with the resulting refinement in the technique of its control.

To hold an accurate setting with manual operation is well-nigh impossible. As the checker temperatures increase, the balance between the stack effects at the inlet and the outlet changes. Also on reversal, the relation between intake and outlet chimney effects is changed and, as a result of these changes, the pressure from the furnace, which remains constant only when the flow of gases into the furnace equals the flow out of the furnace, must vary unless the damper is moved to compensate the change in conditions.

Figure 4 shows a modern type of furnace pressure control adapted to an oil fired furnace equipped with a waste heat boiler. A number of special elements are incorporated to adapt the device to the problem of the open hearth furnaces:

1. A supersensitive measuring element of very low inertia which responds to changes in pressure on the order of .0005 in. water, and fast enough to follow every impulse in the furnace.
2. A relay mechanism which converts these impulses into powerful movements of the relay cylinder and damper without any loss in speed or sensitivity. This includes a complete stabilizing mechanism of the dashpot and plunger type, which gives speed or response proportional to deviation from a set point so that the regulator can move at an infinitesimal rate of speed when required, but can respond at full speed without any throttling whatsoever should a great deviation in pressure occur. This entire mechanism is tightly enclosed in a weatherproof housing to withstand the rigorous conditions of the charging floor.
3. A self-contained hydraulic power system consisting of a built-in oil pump and motor supplies positive drive to the mechanism through a hydraulic piston. Pump capacities are sufficient to give full stroke operation of a waste heat boiler damper in two seconds. The arrangement reduces field piping to a minimum, and insures cleanliness in the oil system.
4. A supersensitive draft gage to check the operation of the controller.
5. A convenient method of determining the control setting by a hand wheel located directly under the draft gage.
6. A simple and convenient throw-over to convert the operation to remote manual control.
7. A position indicator to show the damper or gate position at all times.
8. A manual control lever for positively positioning the damper.
9. Means for temporarily increasing the draft to meet special conditions. If furnace pressure regulation is employed alone on the furnace, then this also can be used as a means of increasing excess air to take care of periods of lime boil, etc.
10. An interlock to take care of such special requirements as might arise during reversal. For example, on oil fired furnaces, there is a considerable volume of cold oil between the shut-off valve and the port, and it is a common sight to see this oil ignite and cause a cloud of smoke and disturb the atmospheric conditions over the bath. This can be prevented by opening the valve gradually and letting the cold charge of oil into the furnace slowly; however, this increases the reversal time and may represent a significant loss in production. When the furnace is on hand control and the damper is not touched during reversals, purging of the furnace occurs after the oil is shut off. Furthermore, when the cold oil in the other end hits the furnace, the suction still being too high, there is considerable excess air being blown into the furnace and ignition takes place very readily without any accompanying puff of smoke.
    The interlock is used to reproduce this condition on automatic control. As soon as the fuel valve is shut off, the regulator is locked into position and retains this position until the fuel is put back on at the other end. If the regulator should happen to be one which acts very slowly, it may not be necessary to do this, but, of course, this condition would be an indication that the regulator was not responding to the fast fluctuations within the furnace between the reversals.
11. Generous pressure connections to the furnace roof and parallel compensating piping must be used to eliminate errors due to chimney effect or temperature head on the regulators.

COMBUSTION CONTROL

Next to control of the furnace pressure the control of the fuel-air ratio and the fuel and air quantities has received much attention although there is still much conflict of opinion as to the mode of control which is justified.

The law of diminishing returns applies in some cases to the combustion controller, since a good furnace pressure controller will increase the over-all furnace efficiency tremendously, and having accomplished this much, it is obvious that the combustion control has more of a problem to justify the expense of its installation. As a result, there has been a tendency to compromise with combustion control systems and to use partial systems in order to save first cost. The author feels that this sort of compromise is hard to justify, unless specific conditions are favorable.

Master Type. For single fuels the most common arrangement is that shown in Figure 6. This consists of a fuel-flow regulator and an air-flow regulator and a master loading device for determining the operating setting of the two regulators. The master loading

devices consist fundamentally of an air tunnel whose pressure is determined by the spring loaded air bleeder cup valve, which is under the control of the operator. The air in the tunnel is led into separate compartments, each of which is connected to the master loading diaphragm of the regulator. Some of the air is bled from each of these compartments through an adjustable orifice and by properly proportioning these orifices, the ratio of air pressures in these compartments, consequently between the pressures in the master loading diaphragms, is made proportional to the air flow and fuel flow differential pressures of the fuel air regulators.

The diaphragm of the regulator measures the rate of flow of the quantity to be controlled and balances the force which is a function of the measured quantity against the master loading air pressure. In its operation the regulator actuates a valve or damper until a perfect balance is obtained between the force due to master loading and that due to fluid flow. Thus a measured quantity is made proportional to the loading pressure in the original master tunnel. Gauge tubes are provided on the master panel to interpret these

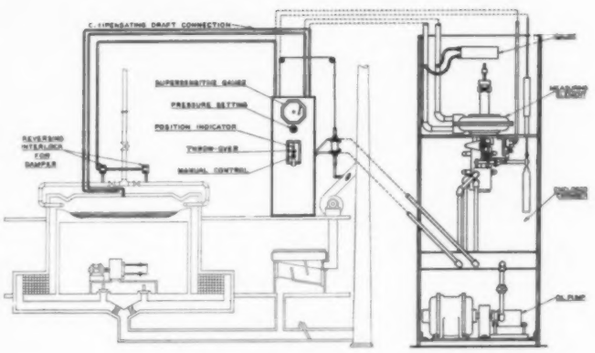


Fig. 4—Typical control for open hearth furnace pressure.

settings and pressures so that the operator knows at all time the amounts as well as the ratio of the fuel and air quantities.

Changes in *fuel-air* ratio, or adjustments for different quantities of excess air, is made by varying the size of one of the bleeder orifices. Since certain parts of the heat require an increase in the ratio of air to fuel, to burn off the incidental gasses such as CO given off during lime boil, a second air column is provided with a throw-over cock so that the fuel air ratio can be changed instantly. This takes care of the temperature disturbances in the balance without disturbing the main setting. The arrangement insures actual setting of the fuel and air, and as previously explained, both are necessary to insure accurate control of the rate of heat input to the bath.

The *fuel-air ratio control* shown in figure 7 is a substitute for the master type of control. Its field of application is where additional means are provided for insuring the proper fuel setting. The fuel and air are both measured with individual diaphragms and the resulting forces are balanced against each other by the regulator which controls the flow of air. This arrangement keeps the fuel and air properly proportioned at all ratings. The control can be provided with means for changing the ratio (to accomplish the same thing as a high low air control described above). This is usually a throw-over switch and a manual control lever to permit a hand setting of the damper, should the first helper so desire. A reversing interlock switch is also provided so that during reversals the air flow may be continued at any rate desired in order to purge the furnace or accomplish any mode of air flow control that may be desired during the reversal period.

Controls of this nature are successful where thorough studies have previously been made as to the actual fuel air ratios that it is desired to maintain, and also where it is possible to meter and set the fuel rate accurately by hand. Where oil, pitch and tar are being burned, the latter is particularly difficult to do, since the valve setting is a very inaccurate way of determining the fuel rate. Constant pressure before and after the valve are necessary, and this would mean a separate pressure regulator for each furnace. Where common pressure regulators are used any change in flow or reversal of any one of the furnace affects the fuel rates flowing from the same line. Furthermore, changes in temperatures exert a tremendous influence on accuracy of the setting. It may be possible to hold fairly constant temperature at one point in the line, such as at the location of the orifice. However, if the valve setting is to be used as a criterion of fuel rate then the temperature at the valve and at all points along the line where any pressure drop occurs must all be kept within certain limits; otherwise, the errors due to viscosity changes and will cause considerable variations in the flow for a fixed valve setting.

It is interesting to note that the control practice developed in some mills is absolutely contradictory to the type just described. Having found that it is very difficult to maintain desired fuel ratings, the operators have recommended the installing of fuel flow controls without including the fuel air ratio control. Or they have placed the fuel control in the hands of the first helper. Here we have two diametrically opposed schools of thought, and the author has noted the opinion of operators in both cases is colored by their own personal experience and by the conditions peculiar to their own mill. The author, of course, feels that where liquid fuels are being used each of these modes of operation alone, is insufficient to give satisfactory control. If it is realized that the primary function is metallurgy and production, it must also be realized that what is of interest is the rate of heat input to the bath, and the total amount of heat transferred varies considerably for the given fuel rate if the air flow is not kept in proper proportion. It is true this problem is not equally as important on furnaces that are fired with straight gas, since it is very simple to hold a standard rate, although the use of mixed gases complicates the problem.

In designing elements for measuring the heavy fuel oils considerable difficulty exists in obtaining the requisite accuracy and still make the element rugged enough to withstand the strenuous operating conditions. The element shown in Figure 8 is a recent development

and can be used on pitch and tar as well as oil. The measuring device is a plunger or free moving piston, instead of the conventional diaphragm or bellows, which is suspended from the balancing weigh-beam of the regulator by a small diameter spoke. The oil feed line is joined to the body of the measuring element and the measuring orifice is included in the casting which houses the piston. In this way the entire element is kept hot without the necessity of steam jacketing, and a very sensitive measuring element is obtained without the disadvantages of a diaphragm. This newer construction was developed for installations where pitch is being burned. Experience has shown that where there is a tendency for the fluid to harden in the measuring element when the line is shut down, it is impossible to prevent a diaphragm or bellows from bursting.

Recently an orifice with a rounded contour such as that shown in the figure has been adopted for measuring the flow of heavy oils over a wide range of conditions. With the typical heavy fuel oil the change of viscosity with temperature is an important consideration even at the high temperatures at which most of these measurements are made. The measuring element must be designed so that it creates a very large differential pressure, thereby giving a high velocity in the orifice. Proper designing will bring the Reynolds number to about 1200 for the heaviest oils at 200 degrees Fahrenheit and 400 gallons per hour. A drop in temperature to 175 degrees will change the Reynolds number to 600, and as shown on the curve, this produces a change in discharge coefficient of less than one-half of 1 percent. This is not true of all orifice shapes, and is quite possible for errors of the order of 8 percent to creep where the orifice is improperly designed.

The care which must be exercised in building the measuring orifice to insure proper fuel measurement, throws some light on the difficulties involved in holding a constant fuel rate without a regulator.

Multiple Fuels. Control of multiple fuels is very easily accomplished wherever the air supply can be split up and a measured quantity of air proportioned to each individual fuel. A fuel-air ratio controller is required for each fuel. The principle of the control is just the same as if each fuel was being fed to a separate furnace.

If the air duct cannot be split up a different problem exists, because the fuels cannot be totalized together, then measured for the purpose of control. The individual flow measurements must be totalized together, and this involves the addition of square root quantities, which is rather difficult to accomplish mechanically.

Figure 9 shows a simple method of adding several fuels, whereby a series of secondary air flows are substituted for the individual fuel flows. This is the same as making a small scale reproduction of the fuel arrangement, but with the flow of air replacing that of the fuels. To measure the total fuel flows, all that need be done is to add the three air flows by joining them in a common duct and to measure the total air flow. Referring to the figure, each of the fuel flows F-1, F-2 and F-3 is measured by some differential medium suited to its individual characteristics; thus, the square root of h_1 is proportioned to the flow of F-1. By means of the Regulator R-1 differential pressure is

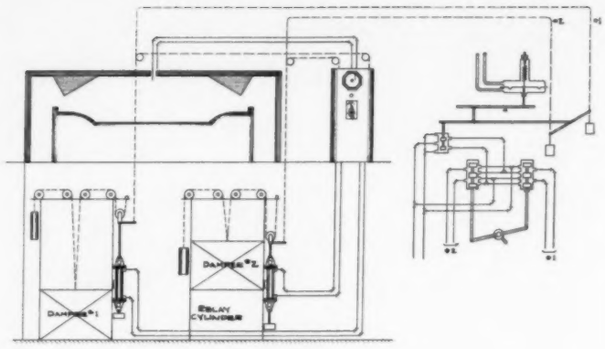


Fig. 5—Reversing valve control.

balanced against the master loading pressure P-1. Air is supplied to the vertical tunnel and leaks out of the three bleeders so that the quantities Q-1, etc., are proportional to the square root of P-1.

Then

$$Q_1 = K_1\sqrt{P_1} = K_1\sqrt{h_1} = K_1F\text{-}1$$

Likewise

$$Q_2 = K_2\sqrt{P_2} = K_2\sqrt{h_2} = K_2F\text{-}2$$

And

$$Q_3 = K_3\sqrt{P_3} = K_3\sqrt{h_3} = K_3F\text{-}3$$

Therefore

$$Q_1 + Q_2 + Q_3 = K(F\text{-}1 + F\text{-}2 + F\text{-}3)$$

But

$$f_A = Q_1 + Q_2 + Q_3$$

Therefore

$$f_A = K(F\text{-}1 + F\text{-}2 + F\text{-}3)$$

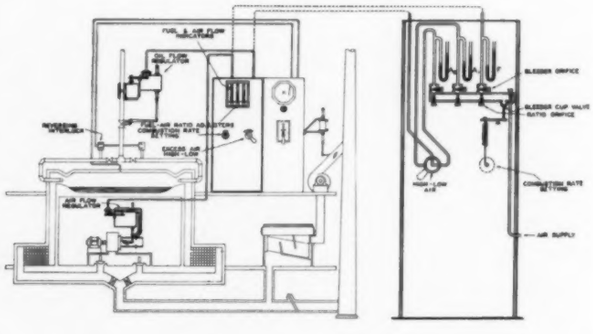
Or

f_A is proportional to the total fuel flow.

The bleeder cup valve is balanced against a spring and determines the pressure in the tunnel. The spring tension is set by the operator to give any desired master loading pressure; this is measured by the gauge columns P-1, etc. The differential pressure P_A is measured drop across one or both of the orifices, and consequently the square root of P_A equals Kf_a. The regulator R_A controls the total air flow which makes h_a equal to P_A, and since the square root of h_a equals KF_A, the total air F_A is made proportional to the total tunnel air or F_A = constant x f_a. Hence

$$F_A = K^1(F\text{-}1 + F\text{-}2 + F\text{-}3)$$

Fig. 6—Open hearth control. Master type.



Therefore, the total air is proportional to the total fuel flow.

The proportionality must be such that F_A equals the total air required to burn three fuels regardless of the ratio of the fuels. Thus, the air flows Q_1, Q_2 and Q_3 must be proportioned not to the actual fuel flows, nor even B.T.U. of each fuel, but to the actual air requirement for the given volume represented by each setting. Thus, if the flows F-1 and F-2 represent the same total B.T.U., the flows Q_1 and Q_2 would differ with the ratio of the excess air requirements. This is, of course, of primary importance in burning gases such as blast furnace and coke oven.

This adjustment is made by changing the sizes of the bleeders at Q_1, etc., so that for a given pressure the flow is proportional to the weight of the fuel multiplied by the theoretical air to fuel ratio plus excess air requirements of the individual fuel.

Figure 10 shows the actual arrangement of such an installation. Instead of the mercury columns shown with the preceding masters, a multiple pressure and draft gauge is used to indicate the various loading pressures. This is rather important since much greater flexibility in the range of pressures is necessary here than is available with the fixed mercury column. The manual controls are similar to those of the standard fuel air ratio controller shown in figure 7.

An adjustment is provided below each fuel gage so that any fuel rating may be obtained. This does not alter the ratio of air requirement to fuel, since this ratio is set by the bleeder, therefore, a change in fuel rating does not upset the excess air requirements of the various fuels. This type of master is characterized by the fact that the operator sets the loading pressure which determines the fuel rating, and the air always adjusts itself to balance the total fuel. Thus, if the operator wishes to cut back on his fuel, he can shut off any one of the fuels, for example blast furnace gas, by closing the corresponding valve on the master, and the air supply will automatically reduce itself to the proper quantity for the remaining fuels. This differs from the other type of master described below, in which the total fuel is kept at a constant value so that a cut back on one fuel will be accompanied by a corresponding increase in the other fuels.

Two settings of excess air are available to the operator by switching over the totalizing differential from one to two orifices. This is the equivalent of the high-low air adjustment on the single fuel master, and enables the operator to increase the excess air for periods of lime boil instead of the other alternative of cutting back the fuel.

Another mode of operation Fig. 11 differs from the one just described in that the operator sets the total heat input by setting the total fuel and air at a constant rate. Should he decide to cut off one of the fuels, instead of the air supply being cut down to match, the other fuels would automatically increase their rating to come back to the original total setting of heat input or total fuel.

The mechanism differs in some other respects, and the figure shows a more completely engineered arrangement with the following attachments, any one of which could be added to the system shown in Figure 10.

Instead of one air indicating column this system has two, so that both the high and low air settings are always visible. There is also an additional total fuel indicator, which for practical purposes is the same as the total air; except that it gives a visible indication of the action of the fuel totalizer, and also enables one to read total fuel-total air ratio readily.

There is a bleed cock which can be used to shut off the loading pressure and drop the entire rating to zero. This is convenient for the multiple fuel device of this nature, since this addition saves four operations on the fuel valves alone. The air may be cut back to zero or decreased to a minimum if purging of the furnace is desired.

A fuel ratio control permits changing the ratio between oil and gas very readily to a calibrated setting. This has certain advantages over the method of ad-

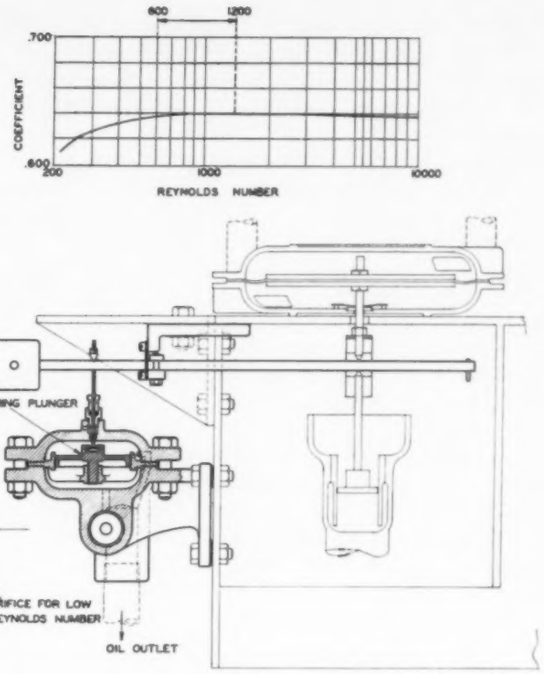
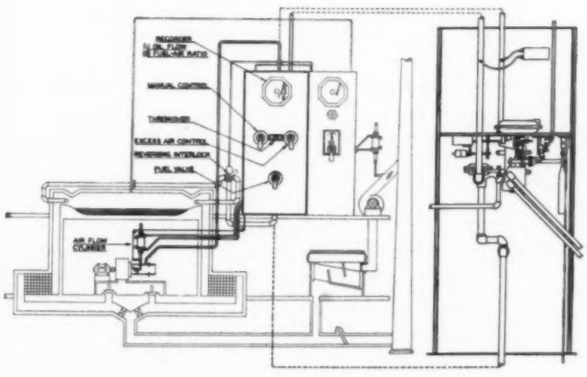


Fig. 8—Fuel oil measuring element.

Fig. 7—Typical fuel-air ratio controller open furnace—oil fuel.



justing bleeders, which requires a higher degree of care on the part of the operator.

The system of multiple fuel control shown in Figure 10, is the simpler and less expensive of the two. It involves a regulator for each fuel, plus a single air regulator, plus a pressure measuring instrument, and if desired, the convenient hand control arrangement shown. The writer feels that it is simple enough to warrant adoption in favor of the other alternative, which is to split up the air on the incoming side of the forced draft fan into three ducts and proportion the air flow in each of the ducts to one of the fuels. There is a saving of one regulator, but there is still the problem of handling and adjusting the three individual fuels, and also the problem of individual pressure regulation to each in order to approach constancy of fuel rate. The cost of such control must be balanced, not only against the three proportioning regulators and the extra duct work required, but also against the mechanism required to provide convenient fuel regulation and the instrumentation necessary to make possible the adjustment of fuel ratios.

MISCELLANEOUS MECHANICS OF CONTROL

Many special problems are met with in open hearth control that are unique to the steel plant. The problem of sensitivity of measurement is always reoccurring in connection with the steel plant furnace, due to the mere atmospheric conditions which characterize most of them. The heavy slide dampers and the tremendous frictional forces found in the open hearth and reheating furnaces, create a requirement of tremendous power and ruggedness in the operating gear that has become well standardized and needs very little amplification at this date. The development of the turbo-governor in the generation before went through the same general period of weeding out various types of operating media, finally adopting the oil operated governor universally as a standard. It has been pointed out that the steel industry seems to be following suit, and where eight years ago there were many types of electric governors on the market, almost all manufacturers are now offering oil operation in some form or other.

Producer gas fired furnaces involve the problem of feeding fuel in proportion to demand in the open hearth. In many cases, this proportioning is left to the operator and the control merely involves bringing air and steam in proportion to the whole with constant gas pressure. While producer gas is still an important source of fuel for the open hearth, newer developments in the use of regenerated mixed gases, natural gas, and mixed liquid and gaseous fuel are gradually replacing the producer as a source of fuel, and, therefore, very little progress in the art of controlling producers has been noted in the last few years.

Special problems have come up, however, among which one worth mentioning is the method of controlling and reversing the Isley stack. The control is similar to the ordinary open hearth control, and Figure 12 shows one such typical arrangement utilizing furnace pressure regulator and fuel-air ratio regulators. The reversing mechanism presents a unique problem, particularly due to the tremendous change in capacity required of the fans when they switch from forced draft duty to induced draft.

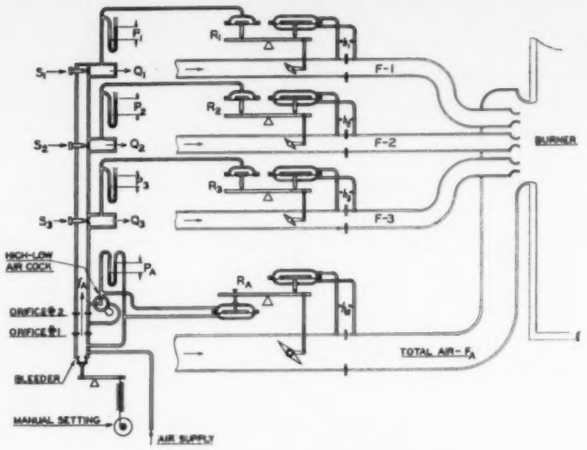


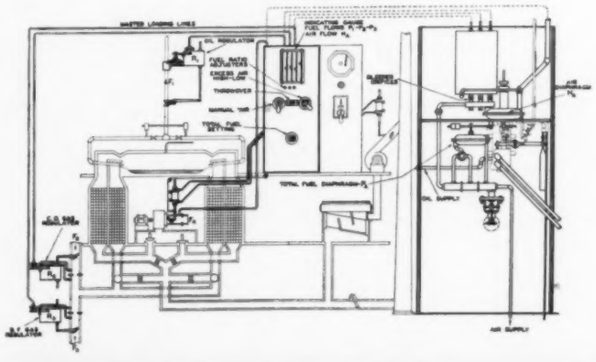
Fig. 9—Schematic multiple fuel control.

When the fan is working on the forced draft side, it must be slowed down, sometimes to one-fourth its normal speed. On the induced draft side, on the contrary, it will probably take all the capacity that the fan has to create the necessary suction. This usually requires either excessively large field control motors or a combination of field and armature control for the service on forced draft. Obviously, it is impossible to switch the rheostats from one motor to another by the ordinary switching method without some form of synchronization of the speeds.

Tracing the operations for reversal of the control shown in Figure 12, first, the fuel valve is shut off; then the reversal transfer valve is thrown, starting the unique series of operations:

1. The air valve to the damper cylinders causes the stack dampers to switch their positions.
2. Simultaneously, the fuel-air ratio regulator is disconnected from the fan and connected to the inlet of the fan which will supply the forced draft after the reversal.
3. A contact is made which energizes a solenoid coil in each of the regulators. In the furnace pressure regulator the solenoid pulls the balance beam in such a direction as to cause the rheostat of the furnace pressure regulator to move toward its *slow* speed position. In the fuel-air ratio regulator, the movement is toward a center position corresponding to full armature current and minimum field resistance. On the fuel-air ratio regulator two solenoids interlocked with position switches on the rheostat of the low speed motor are required. In this way no matter on which side of the above-mentioned position the regulator

Fig. 10—Typical multiple control Type A element. Fuel set—air proportioned.



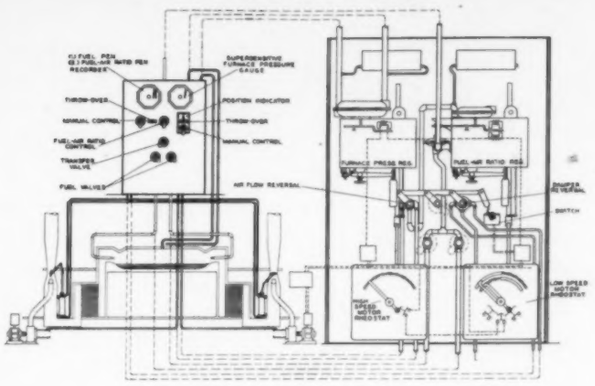


Fig. 12—Control of Isley stack.

may happen to be, it will move to the synchronizing position.

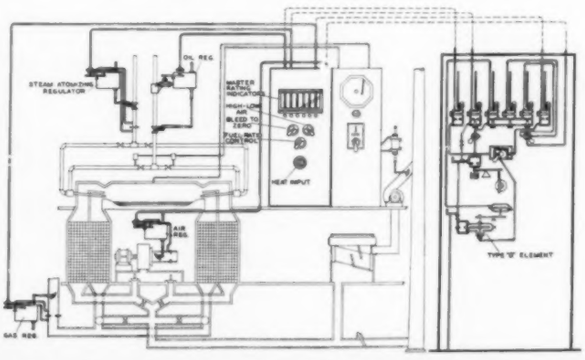
When both rheostats have moved to this position (a matter of two or three seconds) a pair of switches are closed which energize the contactors which reverse the connections between the rheostats and the motors. This immediately cuts out this reversing circuit and the rheostats come under the control of the regulators directly, and move quickly to their normal position causing the fans to speed up. The helper then throws over the other fuel valve and the reversal is complete. A reversal of this type makes it possible to reverse the furnace within eight to ten seconds and no skill whatsoever is required. The timing of the various electrical connections can be arranged so that any degree of purging of the gases of the furnace may be obtained.

CONCLUSIONS

There are two aspects to the problem of control. One is the apparently conservative method of trying out control on one function after another. It implies little confidence in control and timidness about expenditure of money. Control when tested in this manner often does not get a fair chance, and quite frequently it is deemed to be a failure due to the lack of a completely engineered trial.

The other alternative is to equip one furnace in the mill with complete, or even over-elaborate control equipment, and make of this unit a true laboratory for determining the effectiveness of the control as applied to the particular installation. Starting with surplus power, surplus speed and even surplus regulators, experiments are made to determine the combination of controlled and uncontrolled elements which best suits the conditions unique to the particular installation. By cutting back from the most elaborate system, and by thoughtful weighing of each of the elements in relation to the others, the ideal system for a given mill can be logically determined.

Fig. 11—Typical multiple fuel control.
Type B element—constant air



DISCUSSION

PRESENTED BY

G. M. CAUGHLIN, Combustion Engineer, American Rolling Mill Company, Ashland, Ky.

A. F. SPITZGLASS, Vice President, Republic Flowmeters Company, Chicago, Ill.

M. J. CONWAY, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

E. C. McDONALD, Combustion Engineer, Republic Steel Corp., Cleveland, Ohio.

M. J. BRADLEY, Engineer, Leeds & Northrup Company, Philadelphia, Pa.

H. H GORRIE, Bailey Meter Company, Cleveland, Ohio.

G. M. CAUGHLIN: There is one thing I wanted to ask Mr. Spitzglass—if you have not overlooked one very important control.

We have a half dozen kinds of controls on open hearths, just to take care of the combustion. I am sure if we had a mixture of gases, like blast furnace and coke oven gas, we would not at all be satisfied, if today we had a final B. t. u. of 350 in the mixture of the gases and the day after tomorrow we had a final B. t. u. of 450, merely because of the change in either the blast furnace gas or the coke oven gas B. t. u. value. We would certainly put in a calorimetric control on the fuel. If we had a 10 per cent fluctuation in the B. t. u. on total fuel entering the furnace due to lack of control, one of the first jobs would be to correct that condition. However, we have that condition in lack of control of the air.

I noticed yesterday I was quite uncomfortable, even in this air-conditioned room, because of the barometric conditions. When we got outside we noticed the barometer was a little lower than normal and the temperature a little higher than normal, which meant that each cubic foot of air had a certain weight, determined by those conditions. This morning when we came down here we found the thermometer down low and the barometer rising, which means a different weight of air per cubic foot.

What we are after is not air. We are after the oxygen. Why are we not continuing to develop our controls to take care of this wealth that can be calculated? In three days' time we could have a 14 per cent difference in amount of oxygen for the same cubic foot of air passing through the fan.

I may have misunderstood Mr. Spitzglass. I understood him to say that the pressure within the furnace caused the flame to seek a lower level. Rather did you not mean the pressure prevents the air from entering the furnace? You are speaking about the pressure within the furnace. The pressure does not cause the flame to seek a lower level. It merely prevents the atmosphesic air from entering the furnace.

This question of velocity over the bath is very important. We design a furnace, and unless we take care of the fuel-air ratio, we cannot take care of the velocity to the point for which that furnace is designed.

The question of flame direction is again a question of design of the furnace. If it is designed for the best combustion condition and if we allow an additional air supply (more than is necessary) to enter through the port and exit through the outlet port, we are really handicapping ourselves. This fuel-air ratio is necessary in order to get the B. t. u. per ton for which we are all striving. It is just too bad we do not have an open hearth furnace where we can have a burner and a flue. The fact that we try to make a burner out of a flue and a flue out of a burner just shows that we are not smart enough to design the proper kind of open hearth furnace. I believe that will beat all the controls in the world.

May I ask Mr. Spitzglass to be a little more definite on the action of his control to take off fuel, which we buy in the form of gas or oil, during the lime boil, in order to have enough air to take care of the gas coming from the bath? It was not quite definite enough.

A. F. SPITZGLASS: Mr. Coughlin's question with regard to the variation in the amount of oxygen in the atmosphere is important, of course, but in the method of measurement described in the paper, the total error introduced is not as great as it would be if we were positively measuring the volume of gases. Actually, our measurement is by a differential pressure that varies with the square of the weight of the gas. As a result of this squared relation, the change in differential head on our control diaphragm, due to variation in the density of the gas produces an error only half as great as though the weight of the gases was being measured by a weighing method.

Referring to the simplified formula, $W = K\sqrt{h\delta}$, it is very simple to demonstrate a change of 14% in "δ" only causes a change of 7% in "W".

Furthermore, when we are controlling, we set our air flow for an average condition, and split this error so that this can be considered a maximum error of 3.5%. In other words, for the rather extreme condition cited, the maximum actual error in the fuel-air ratio produced by change of oxygen weight per cubic foot of air will be 3.5%, and in actual conditions it would be well within this amount. Obviously, Mr. Caughlin is right in saying that we should attempt to go further and not be satisfied with an air control accurate only to 3.5%. Apparatus is available to accomplish this by correcting for specific gravity and even barometric pressure, but in its present form is rather involved. The control of air within a few per cent, however, represents a practice that has not yet been achieved by the Industry in general, and, therefore, great improvements can be made with the simplified equipment, as described in the paper.

With regard to the second question, it is agreed that the main value of retaining pressure under the roof is to prevent air from entering the furnace. It is also agreed that the pressure itself does not cause the flame to seek the lower level.

However, the writer mentioned the fact that it keeps the flame down, because there has been considerable comment, at certain of the Open Hearth meetings of the Society, regarding the effect of pressure upon the flame direction. The discussions seem to indicate that there is a relation. It is the writer's opinion that the flame direction is affected secondarily. A pressure under the roof limits the infiltration to the openings in the doors, and therefore there is a tendency for a condition of excess air to exist just above the bath. The flame will, of course, burn toward this source of excess oxygen, and the general effect is to help the flame to hug the bath.

The third question, in regard to cutting off fuel to take care of lime boil, might be more clearly answered by stating that the cutting off of the fuel and the increase in the percentage of air are two separate operations. The only advantage of being able to cut one fuel off entirely for lime boil lies in the case where the management wishes to predetermine the operating conditions and set fixed values in proportions for cutting back fuel. After this is done, then the high air throw-over is operated to increase the excess air sufficiently to burn off the lime.

The writer knows of several installations where the management has found it to their advantage to adopt this mode of operation, and the two modes of operation, while they are quite similar, are described to show the possibilities of adaptation to the slight difference in operating method existing in various plants.

G. M. CAUGHLIN: May I have a moment again? There was a misunderstanding of my first question. We have in our cupolas blowers now that are oxygen blowers, weighted-air blowers. Why can't we do the same thing with the open hearth? If we are going to use the air ratio control, let's really control pounds of oxygen and not cubic feet of air, by our controls based upon barometric pressure and temperature readings? Why not take care of the fluctuations in pressure and temperatures? I have an idea there has been quite a difference in the last twenty-four hours. Why not take care of our air-gas ratio as oxygen ratio, and do it mechanically on the inlet fan, if it can be done? That is what I meant.

M. J. CONWAY: Mr. Spitzglass has presented us with a paper to which he has given a lot of time and thought on the practical application of open hearth furnace control. Adding to his remarks, a control should be designed and applied with ease of maintenance and adjustment in mind.

Furnaces that are tight and reasonably well insulated will do better on control, than furnaces that are just thrown together with no thought of air infiltration.

Sufficient instruments to check both the control and the operators judgment should be installed, and credit given to the control for the subsequent improved practice on the uncontrolled furnaces.

E. C. McDONALD: Mr. Spitzglass is commended for his comprehensive presentation of automatic control for Open Hearth furnaces.

There is another method of combustion control not discussed in the presentation that I believe has possibilities if some of its present difficulties are eliminated and the equipment is marketed at a substantial reduction.

The control to which I refer regulates air imput to the furnaces by the quantities of CO or Oz in the waste gas as analyzed automatically at the down-takes or slag pocket. By this method the addition of excess air or the reduction in fuel imput during the periods of CO liberation from the bath is automatically taken care of. To minimize air infiltration furnace pressure control would be part of the installation.

I believe too, there are advantages in the scheme of controlling fuel imput to the furnace from roof temperature. By this plan fuel is fed to the furnace automatically to maintain maximum allowable refractory temperature. To prevent an excess of fuel flow at any time, a restriction should be inserted in the fuel line. This scheme drives the furnace at maximum flame and roof temperature and at the same time gives a margin of protection by installing a fuel shut-off.

Both of these schemes have been used on open hearth furnaces, but to my knowledge, the two features have never been coordinated on one furnace. I would like to see the control manufacturers further develop both of these ideas.

All of us interested in open hearth combustion problems realize that the benefits to be derived from the installation of automatic equipment depend, almost entirely on how bad we were before the control was installed. Fuel practices of 3,800,000 B.T.U.'s can be made on completely insulated 140-ton furnaces without any control if given the supervision that usually goes with automatic features. In my opinion though, I believe all open hearth furnaces, with ample draft to regulate, should be equipped with furnace pressure control to take the manipulation of the stack damper out of the operator's hands. As for complete combustion regulation I believe a saving of 200,000 B.T.U.'s per ton can be shown on a furnace that formerly had been well operated manually. Evaluated in terms of fuel only at $ .25 per million B.T.U.'s, a savings of $ .05 per ton or $3,750.00 per year on 75,000 tons should be made. This savings represents a return of approximately 100 percent.

M. J. BRADLEY: Mr. Spitzglass has discussed the subject of combustion control in open hearth furnaces from a theoretical point of view and has tied in the theoretical considerations with the practical operations as carried out in many open hearths shops. I agree fully with the assumption that efficient fuel utilization in the open hearth furnace does result in quality and increased production. However, automatic control equipment in itself is not a panacea for faultily designed or obsolete open hearth furnaces. An open hearth furnace must be controllable manually; otherwise, the results to be obtained from automatic control equipment may be disappointing. Automatic control equip ment on open hearth furnaces cannot think, cannot make steel. It is only a tool for the first helper to obtain the operating conditions he desires. It should maintain accurately the set conditions until he subsequently changes them. It should enable him to operate the furnace efficiently.

Several of the topics covered have been discussed in previous meetings. For example: Furnace pressure or stack draft control. However, there still exists several schools of thought on this subject and many different methods are to be found operating in open hearth shops to maintain a certain furnace pressure condition which may be varied for different stages in the heat. To illustrate: In some shops the speed of the induced draft fan is varied; in others, a gate damper, louvre or butterfly damper may be adjusted in the flue or stack and, in other shops, cold air is admitted at the base of the stack. In general, the various methods are intended to maintain a relative pressure condition within the furnace sufficient to stop the leaks or infiltration of cold air which lowers the flame temperature and decreases fuel efficiency. Metered combustion control on open hearth furnaces is growing rapidly in favor. In fact, it has been installed on the majority of the new furnaces which have been built recently. When the combustion control is operated automatically or by machine, as discussed by Mr. Spitzglass, several methods have been employed.

The electrical method of control employs electric motors for driving purposes and electrical current for loading the controllers. This method lends itself readily to the control of multiple fuels. An auxiliary loading current is established proportional to each fuel rate and the several fuel currents are totalized to set up the required loading for the combustion air controller. Thus, only one air supply measuring element is required for any number of fuels.

A great number of control units, functioning by the electrical method are operating on open hearth furnaces. The majority of these units are operating at two or more rates of speed. Contrary to what Mr. Spitzglass appears to wish us to believe, the electrical method of control is doing a good job and enjoys a very favorable position in the open hearth industry.

A. F. SPITZGLASS: Mr. McDonald brings up the question of controlling air input by analysis of the waste gases. This method of control was not described in the paper for the simple reason that it is not a commercially practical one to recommend as yet. Considerable experimental work has been done in this direction, but the stumbling block has always been not so much in the method of control as in the method of measurement.

The author has had considerable experience with instruments of this type and does not hesitate to recommend them as a means of checking the action of the control, but to actually use them as a criterion to guide a controller is out of the question on account of the time lag involved in making the measurement as well as the general lack of sensitivity, especially in

instruments used for measuring oxygen. The conditions in the open hearth furnace are changeable, and an indication of what has already happened is of little immediate value to an automatic controller. They are invaluable, nevertheless, as a guide for better practice.

With regard to controlling fuel input from roof temperature, this is undoubtedly a valuable complement to the standard combustion control when it is used as a safety cut-back of the fuel rate. It does not primarily affect the question of combustion control, and therefore has not been discussed in great detail; but as Mr. McDonald points out, it is invaluable in permitting automatic operation at maximum allowable refractory temperature, although the problem of obtaining the roof temperature is one that still requires study.

The author also agrees with the statement that economical fuel practice is possible in well-insulated furnaces without automatic control, given proper attention. The thing that has made automatic control as popular in this country as it is, however, is the elimination of the "human element" factor. Under the conditions obtaining in the average mill and open hearth shop, the ideal mode of operation is almost impossible to obtain over long periods of time, and it is this consistant day in and day out repetition of conditions that is the best insurance for uniformly reduced costs. As a result, automatic control, even on a good furnace, must be prepared on the basis of long period results.

Mr. Conway's emphasis on ease of maintenance and adjustment is pertinent. The arrangement shown by the author have all been designed with these considerations in mind, and the operations involved have been reduced to an absolute minimum.

The question that Mr. Bradley brings up, the adaptability of furnaces to control, of course, is a very important one. Obviously, metered control infers the possibility of metering the functions involved and this is not always possible to accomplish with any degree of refinement in the older types of furnaces. Designers of modern open hearth furnaces realize this and provision for better control is being incorporated in most of the new furnaces being built.

On the other hand, the older furnaces, although not ideally suited to give the greatest refinement in accuracy of control, still offers such possibilities of savings that modified systems of control can be applied with great success. For example, the more leaky a furnace is, the more important it is that we control the furnace pressure. Therefore, while improved furnace design is the ideal of both operator and control engineer, the application of control to relatively obsolete furnaces represents a very important phase of this problem.

H. H. Gorrie: Mr. Spitzglass is to be complimented on the very thorough and interesting manner in which he has covered this difficult subject.

There are, however, one or two points covered in this paper on which a different point of view may be of general interest.

Mr. Spitzglass points out correctly that the four essentials of a good regulator are—sensitivity, speed, power and stability. He further states that speed of operation coupled with power and stability is more difficult to attain with pneumatic drives than with hydraulic drives. This is true so far as the mechanics of the problem is concerned, but identical results may be obtained through proper design and arrangement of equipment. Just as speed and power attainable from a hydraulic piston is dependent upon the oil pump size, so the speed, power, accuracy and stability of the air cylinder is dependent upon the quantity of air used and the design of the compensating relay supplying the air to the piston.

A high speed drive is not always required, and where it is not required it is sometimes good economics to decrease the pump size or the quantity of air used to some reasonable value.

The fuel—air ratio arrangements discussed by Mr. Spitzglass are based on the "force balance" system of control. Although this system has its advantages, it is very difficult to control fuel—air ratio where multiple fuels are involved. Control can be accomplished wherever the air supply can be split up and a measured quantity of air proportioned to each fuel. This method is expensive both in its installation and in the amount of equipment involved, and in addition may require considerable space at a point where space is at a premium.

With the "force balance" system of control, the problem becomes considerably more complicated if the ducts cannot be split up. In this case the individual fuel flow measurements must be totalized, involving the addition of square root quantities which is rather difficult to accomplish with this system of control.

In contrast a control operating from flow meters of such design as to extract the square root relation between flow and orifice or nozzle differential is a simple solution to the problem. The equipment consists of separate meters for liquid and gaseous fuels arranged to record total fuel in B.t.u. per hour, and a third meter to record the total Air Flow. The control is operated directly from the meters to maintain the desired ratio of total air to total B.t.u. input. Simple adjustments are provided to compensate for variations in the B.t.u. content of each fuel. An adjustment may also be provided to vary the ratio of total air to total B.t.u. input. These adjustments are percentage adjustments and therefore maintain the desired relation at all rates of flow.

A. F. Spitzglass: Mr. Gorrie's comparison of pneumatic and hydraulic drives is true only within a limited range of application and only in a restricted sense. The pneumatic drive introduces a definite limitation, namely, the compressibility of the air. Therefore, in actual application, as well as theoretically, under the same set of circumstances, it produces another source of time lag. This means that identical results cannot be obtained. If fast operation is unnecessary, the results may be satisfactory; but for pressure regulation, speed is a very important element and is only sacrificed at the expense of accuracy.

The difficulties referred to in totalizing multiple fuels are very readily eliminated by the simple scheme shown in Figure 9. The method eliminates the problem of adding square roots, and simple adjustments are provided, not only to compensate for variations in B.T.U. content but also excess air requirements.

C. F. HOOD
Executive Vice President

H. B. JORDAN
Assistant to Vice President

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ANNOUNCED BY

AMERICAN STEEL & WIRE

C. F. Hood, who has been vice-president in charge of operations of American Steel & Wire Company, Cleveland, has been appointed executive vice-president, a newly created office. M. W. Reed, who has been Mr. Hood's assistant and chief engineer, has been named vice-president in charge of operations succeeding Mr. Hood. H. B. Jordon, who has been manager of the Cleveland district mills, has been named assistant to the vice-president. G. H. Rose, formerly construction engineer, has been appointed chief engineer. B. H. Gedge, who has been superintendent of the Cuyahoga works, succeeds Mr. Jordan as manager of the Cleveland district mills and is succeeded by W. F. Munford, who has been assistant superintendent of the Cuyahoga works. The changes become effective immediately.

G. H. ROSE
Chief Engineer

W. F. MUNFORD
Superintendent of Cuyahoga Works

B. H. GEDGE
Manager Cleveland District Mills

M. W. REED
Vice President In Charge of Operations

STEEL MILL CRANES

▲ THERE are some 15 and 20 ton cranes now in operation with a straight line drive for the bridge motion, as shown in the illustration and built by the Whiting Corporation, Harvey, Ill. These are double drive cranes and each motor is mounted in the center of the span and between the motor and each truck is a gear reducing unit, consisting of two reductions of spur gears so arranged that the high speed and low speed shafts are concentric.

This gear reducing unit is completely equipped with Hyatt bearings having straight rollers, which permit end play, and all bearings are mounted in a steel frame so as to insure accurate alignment. This steel frame is enclosed in an outer steel housing which has a light steel cover easily removable for inspection. This design insures an oil tight unit.

The low speed shafts are extended and coupled directly to the axles. This gives a straight line drive from the motor straight through to the wheels, and allows a straight walk with no offset at the center to accommodate the drive.

The axles are equipped with two opposed Timken bearings on one end, which take the thrust in both directions, and on the other are provided with solid straight roller bearings which permit end play. All bearing housings are equipped with spring compression oil seals.

The trolley hoist units, are completely roller bearing equipped. All bearings of each unit are mounted in a one piece steel frame which insures accurate alignment, and this frame is mounted in a steel housing having an oil tight sheet metal cover which is easily removable for inspection. Herringbone gears are used throughout on the hoist units insuring long life and quiet operation.

Magnet reels are mounted under the drums, and are positively driven by chain drives from extensions of the main drum shafts. The magnet reels are provided with screw driven feeding devices to insure proper reeling of the cable.

The enclosed blocks are completely equipped with roller bearings and the sheaves are mounted on the swivel so as to give the maximum lift. The upper sheave nests are completely enclosed. The trolleys are equipped with double acting spring bumpers which are completely enclosed and so designed that it is not possible for any breaking parts to fall.

The trolley travel is provided through a gear unit completely equipped with roller bearings and herringbone gears which insure quiet operation. This unit is cast in halves and split vertically. One half is provided with feet for bolting directly to the side of the trolley separator, which permits the other half to be easily removed for inspection. The roller bearings are mounted in one piece capsules provided with flanges which are bolted to both halves of the gear case. When the bolts in the outer half are removed, the bearings and gears cannot fall out of position because they are held by the remaining bolts in the inner half of the case. This permits easy inspection of the gears and a check on the alignment.

Tiger Mill type crane, 20 tons capacity with straight line drive.

TRUCK FOR PIG METAL HANDLING

▲ THE modern conventional fork type of industrial high lift truck can now be adapted with success for use in pig handling in the metal refining industries and yet retain general utility for the pallet system of handling usually subscribed to the fork truck.

Mordern conventional fork truck, 4,000 pounds capacity.

The forks are designed to grip the pigs firmly and hence with safety and can be laterally adjusted by a hand crank to handle any length of pig. The sharp bevelled inside edges of the forks enable them to support the pigs by actually biting into the underside curvature of the protruding lip or ear of the pig. This truck has a maximum capacity of 4000 lbs. and is built to turn around in an aisle only 6″ longer than the total length of the truck and load.

The battery compartment permits both top and side removal of the battery, and also the battery connector plug can be quickly disconnected because it is accessible on the outside of the battery compartment. Other salient features are wheel steering through gear reduction, interlocked controller provided with double safety, two sprocket hoist chains, each capable of supporting the load through triple gear reduction, double reduction drive unit, all welded unit assemblies, drop forged chrome nickel steel gears throughout, and weighted drive wheels.

Complete detailed information is available on this equipment by addressing The Yale & Towne Mfg. Company, 4530 Tacony Street, Philadelphia, Pa.

IGNITRON SEAM WELDER

▲ A NEW ignitron seam welder control utilizing ignitron tubes has been announced recently by the Westinghouse Electric and Manufacturing Company. This control times power impulses in terms of a definite number of power cycles to a wheel type electrode resistance welding machine. Among its features is an inductive timer, consisting of a synchronous driven disc rotating once per second and containing 120 holes, each corresponding to a half cycle of welding current. Also, the use of ignitron tubes permits a design utilizing no voltages higher than line voltages and eliminating the need of power contactors and transformers. Steel pins are plugged into the holes according to the timing desired. The new control is simple, durable, and the timing is precise. Its use greatly improves the quality of welds for even very light gauge steels. It is especially suitable for welding heavy gauge steels, demanding heavy welding currents, and special metal alloys demanding accurate timing and often heavy current such as aluminum and olympic bronze.

NEW INSULATING BRICK

▲ JOHNS-MANVILLE has recently placed on the market a new type of 2000-degree insulating brick known as "JM-20".

This new brick, fully protected by Johns-Manville owned patents, was developed by the company's Research Laboratories for use behind refractory walls in open hearth regenerators, in hot blast mains and bustle pipes, in producer gas mains and in various types of furnaces. It can also be used for direct exposure in radiant tube type annealing furnaces, electric furnaces or wherever there is no flame impingement, slag action or mechanical abrasion, at temperatures up to 2000-degrees F.

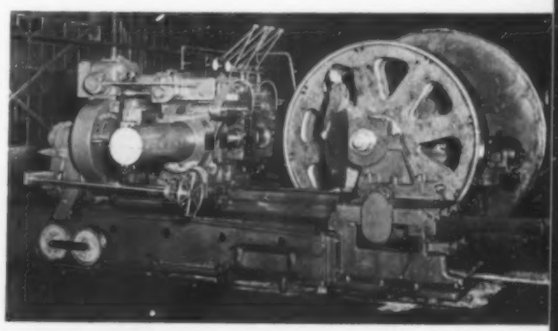
Research on basic raw materials used in refractory insulations led to the development of JM-20 Insulating Brick. This new type of insulation it produced by combining a high quality refractory clay with a specially manufactured, fibrous, light weight, inorganic aggregate.

JM-20 Insulating Brick is unusually light in weight, weighing less than 1.7 lbs. per standard 9-inch equivalent. Its low heat capacity is less than one-quarter that of ordinary refractories—and its thermal conductivity is less than one-sixth that of fire brick.

Data sheets giving full particulars on JM-20 Insulating Brick may be obtained from any Johns-Manville office.

LARGE GEAR GENERATORS FOR RUSSIA

▲ TWO large plants have been established in Soviet Russia for the manufacture of heavy machinery, one of them at Kramatorsk near the Dneprostroi project in the south, and the other, known as the Ural Machine Works, in the north. Both these plants are equipped for manufacturing heavy equipment and the Kramatorsk plant is especially designed for building the heaviest steel rolling mill machinery.



Sykes gear cutting machine built for the Soviet.

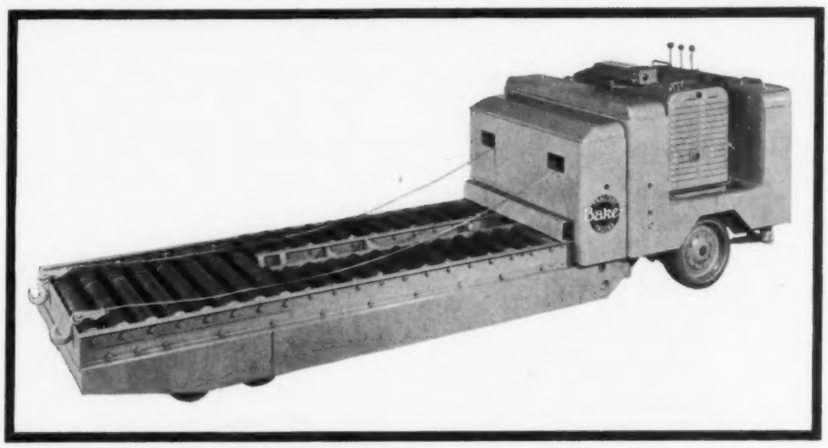
In planning the production of heavy gearing in these plants, it was realized by the Soviet officials that the latest and most highly developed heavy gear cutting machinery was essential

for producing the high quality gears now used in high speed rolling mills, especially in the new type of continuous sheet mills.

Therefore, in 1934, a group of engineers was assigned to investigate in the United States the types of gear cutting equipment available. As a result, a contract was placed with the Farrel-Birmingham Company, Inc. of Buffalo, N. Y., for two Sykes machines. These machines are of a similar design to six others made by the Farrel-Birmingham Company for use in its own plant at Buffalo but they are considerably larger, the one intended for the Kramatorsk plant having capacity for cutting gears up to 8 meters (approximately 26 feet) in diameter, a maximum face width of 1½ meters (about 5 feet) and a maximum pitch of 50 module (6.18 inches circular pitch). The machine for the Ural Works is exactly the same except its diameter capacity is 6 meters (approximately 20 feet).

CONVEYOR ELEVATING TRUCK

▲ THE Baker-Raulang Company, Cleveland, has just designed a 10-ton capacity materials-handling truck which embodies an unusual application of a power-driven roller conveyor to the platform of an elevating truck. The truck was built especially for handling packages of sheet steel and the roller conveyor greatly facilitates the loading and discharge while the elevating feature makes it possible to adjust the height of the conveyor to the level of the run-out tables at the loading and discharge points. An electrically driven double-drum is provided, the cables from which are hooked around the package on the conveyor to hold it securely when traveling at high speeds over rough floors.



Materials handling truck designed especially for transporting packages of sheet steel.

The truck is almost 18 feet long overall and the platform is 10 feet long by 50 inches wide by 20 inches high to the top of the conveyor rolls in the lowered position with a vertical movement of 4½ inches. The total weight of the truck without load is 16,000 pounds and in order to manouver this massive truck easily and effortlessly under its pay load of 20,000 pounds, power steer is provided which requires a movement of the steering controller handle of only about two inches in either direction to operate the motor which actuates the steering on all six wheels.

The conveyor is driven by an electric motor by means of a long propellor shaft of the automobile type equipped with two universal joints which permits driving the conveyor while raising or lowering the platform. Limit control is also provided to shut off the conveyor automatically when the pack is fully on the platform

NEW CHARGING BOXES

▲ A SOLUTION to the problem of breakage of steel charging boxes has been found in the use of a special design of head and a box made of alloy steel.

A steel company which had been having frequent trouble with breakage of boxes in charging heavy grades of scrap ordered a trial lot of 20 boxes from the Union Steel Casting Company, a subsidiary of the Blaw-Knox Company. The boxes, provided with special heads, were made from that company's "Univan," a nickel-vanadium composition which has for many years proved highly successful in locomotive main frames and crossheads, rolling mill pinions, and other heavy duty applications.

As a result of successful use of the boxes, five additional orders were placed, making a total purchase of 200 boxes. In 15 months of use, none of the "Univan" boxes cracked, while some carbon steel boxes bought at the same time cracked all the way through the pan.

Subsequently, three other steel companies have bought a total of 60 charging boxes of this type.

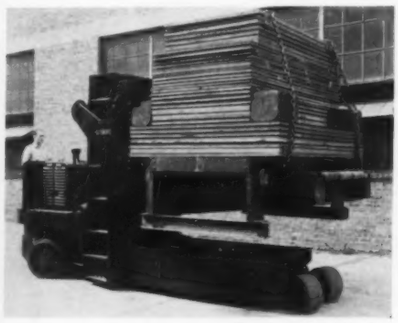
Charging boxes provided with special heads of Univan, a nickel vanadium composition.

so that it acts as a safety feature for the conveyor drive mechanism.

Each individual motion of the truck is powered with a separate motor—the travel, lift, conveyor, winch, and steer—so that all or any desired combination may be operated simultaneously permitting the greatest possible degree of flexibility and allowing full advantage to be taken of the trucks possibilities for saving in handling.

INDUSTRIAL TRUCK GIANT

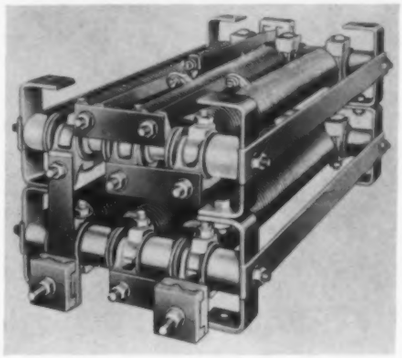
▲ THIS giant of Industrial Trucks has been engineered and designed by Automatic Transportation Company, 101 West 87th St., Chicago, Illinois, for safe handling at various heights of gigantic 30 ton dies to and from the presses and storage and at the lowest possible cost with a considerable saving of time and labor.



Many special design features on this huge truck.

Some of the features which automatic engineers have perfected are powerful dual platform lift units synchronized for equalized lifting of enormous loads on platform by means of four two part massive roller chains. A powerful dual drum die handling unit directly mounted on platform which is capable of drawing and placing 30 ton dies to and from presses and storage. A drive unit designed to give efficient service with newest automatic design V joint universal for driving wheel connections. An eight wheel trailing axle fully equalized and compensating controlled by power steer which permits amazingly easy steering with practically finger tip control. No side sway of platform or pinching of tires is experienced when operating around corners or over uneven surfaces.

NEW RESISTORS



Resistors capable of operating at high temperatures.

▲ THE Monitor Controller Company, Baltimore, Maryland, have developed a new and decided improvement in resistors which has created considerable interest. This resistor includes all the essentials of their Edgewound type and in addition has malleable iron terminal clamps which are supported directly from the frame, relieving the resistor elements of all cable strain and vibration. Heavy pressed steel terminals provide immediate tap connections. The location of these terminals can be easily and quickly changed. All wiring and inter-connections between banks are conveniently made at the end of the frame. These resistors operate at high temperatures without damage and are especially suitable in places subject to vibration and shocks, involving heavy currents and general rough usage.

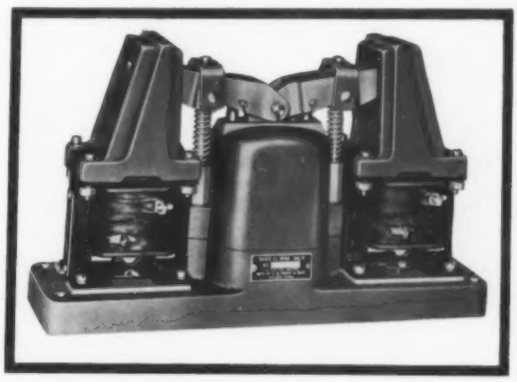
OIL CIRCUIT BREAKERS

▲ A NEW and improved operating mechanism for the Type FH line of oil circuit breakers has been announced by the General Electric Company. Designated the MK-110, the new mechanism supersedes the Type MK-10. By increasing the opening springs and modifying the trip-mechanism to reduce the friction, faster opening time is obtained. This permits rating all breakers—600 amperes to 4000 amperes inclusive—at eight cycles.

Other improvements in the mechanism include an easily operated hydraulic device for manual closing. It is portable and can be operated by one hand. The centrifugal mechanism has been modified to give greater rigidity and ease in alignment at all motor speeds. An improved cut-off switch, more easily adjustable, has been provided. Both the motor and the cut-off switch in the MK-110 mechanism are interchangeable with the motor and cut-off switch of the Type MK-104 unit, used with outdoor and other indoor breakers.

AIR CONTROL VALVE

▲ THIS 6-way valve is a new unit being manufactured by C. B. Hunt & Son of Salem, Ohio. This valve can be operated as a 6-way valve or as a double 3-way valve. When used in the latter manner it affords economies over the cost of two similar



New valve can be operated as 6 or 3 way.

3-way valves. This valve may also be used as a 4-way, compound exhaust valve. Made in $\frac{3}{8}$", $\frac{1}{2}$", and $\frac{3}{4}$" sizes. The Solenoids in this valve operate independently, each having a return spring. In all of the combinations mentioned this valve is normally closed. Can be supplied for normally open operation by special provision on request. Solenoids are equipped with stop brackets. Valve cage and Solenoids are mounted on mounting plate to which piping is fitted. Valve cage or Solenoids may be removed for inspection without disturbing the piping. This valve should be differentiated from the momentary contact type of double Solenoid Valve manufactured by this company.

Items of Interest

M. D. Conroy, heretofore assistant to the general manager of the Granite City Steel Company, Granite City, Illinois, has been made assistant to G. Hayward Niedringhaus, President of the Company. Philip J. Stremmel, who has been general superintendent, has been made vice-president in charge of operations. John H. Vohr has been promoted from superintendent, in charge of strip mills, to general superintendent of plants, B. B. Johnston from assistant to general superintendent to assistant general superintendent, and N. B. Randolph, from assistant general manager of sales to general manager of sales, working under Laurence Miller, Vice-president in charge of sales.

Mr. Conroy received his formal education in the schools of Youngstown and went to St. Louis in 1903 to become identified with the Helmbacher Forge & Rolling Mills Company. A few years later, he was made general superintendent of the St. Louis and Madison, Illinois plants of that company. When these were acquired by the American Car & Foundry Company, he was made general superintendent of the company's plant at Madison, severing his connection in 1930. He became identified with the Granite City Company in 1932.

Mr. Stremmel has been associated with the company and its predecessor since 1893 successively as tin mill roller night and day superintendent of the sheet and tin mills. In 1918 he was made assistant general superintendent and general superintendent in 1928.

Mr. Vohr has been superintendent of the hot and cold strip mills since last January. Following graduation from Cornell University in mechanical and electrical engineering, he was associated with the New York State Railways as an electrical engineer. After serving in the World War, he joined the American Sheet & Tin Plate Company at Farrell, Pa., and later was transferred as assistant superintendent of strip mills to the company's plant at Gary. Since leaving the Company in 1931, he has been associated with the installation and operation of the wide strip mills of the Inland Steel Company and Youngstown Sheet & Tube Co.

Mr. Johnson has been identified with the company for many years, as a sorter in the finishing department and foreman of the finishing and other departments until 1930 when he was made assistant to Mr. Stremmel.

▲

Harry L. Myers has been appointed general superintendent of the West Leechburg division of the Allegheny Steel Company. Mr. Myers, who has been connected with the division since 1915, was formerly assistant superintendent. He succeeds Noble Jones, resigned.

▲

E. A. Hurme, formerly Philadelphia district manager for the Clark Controller Company, has been appointed special field engineer for the Treadwell Engineering Company, Easton, Pa.

Mr. Hurme, after completing his electrical engineering work at the University of Michigan in 1914, joined the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., and for the following thirteen years was engaged in steel mill engineering and sales work; the last six years of which he was manager of Westinghouse steel mill activities.

In 1927, Mr. Hurme became associated with the Clark Controller Company as manager of their Pittsburgh district and has been connected with them in various capacities, up to the present time.

As a member of the Association of Iron and Steel Engineers he has, for many years, served on numerous committees. For the past fifteen years he has been

J. H. VOHR

HARRY L. MYERS

E. A. HURME

GEORGE T. LADD

W. P. WITHEROW

A. G. WITTING

specializing on steel mill applications. His numerous technical articles have been welcome contributions to the steel mill industry's application data.

▲

George T. Ladd, president of United Engineering & Foundry Company, announced upon his return from Japan that his company had been awarded the order for a new 43" continuous hot strip mill to be located in Japan on the island of Kyushu at Shimonoseki, which is located approximately 900 miles southwest of Tokyo.

The mill, of approximately 450,000 tons annual capacity, will be a duplicate of the recently completed hot strip mill of the Carnegie-Illinois Steel Corporation at McDonald, Ohio, which was built by United Engineering.

The Japanese steel plant at Shimonoseki, which employs 40,000 and makes a wide variety of steel products, will utilize the output of the new continuous mill to the extent of 350,000 tons for sheets while about 100,000 tons will be used for rolling tin plate by the cold reduction process.

Mr. Ladd was honored at a number of ceremonials and functions while in Japan because of the fact that his father had been instrumental in revising the educational system in that country. His father, who had been a professor at Yale University, was invited to Japan for that purpose and a stone shaft was erected in that country after his death as a token of Japanese respect to his memory.

▲

W. P. Witherow has been elected the president of the Blaw-Knox Company. Frank Cordes, president, was elected chairman of the board of directors and Chester H. Lehman, vice president, was elected vice chairman of the board and executive vice president.

Mr. Witherow, in assuming the duties of executive head of the company, which includes among its subsidiaries Lewis Foundry & Machine Company, Pittsburgh Rolls Corporation, National Alloy Steel Company, and Union Steel Casting Company, brings a background of steel mill and general engineering and construction experience dating back to 1908, when, as a graduate of Yale, he became associated with the Jones & Laughlin Steel Company. Following this, he became engineer for the Truscon Steel Company and then founded the Witherow Steel Company. After the successful development of the Witherow die rolling process, the company acquired the Dilworth-Porter Company, both of which were later acquired by the Donner Steel Company, Mr. Witherow becoming chairman of the board of the latter company. The Donner Steel Company later became a part of the Republic Steel Corporation, and Mr. Witherow was vice president of Republic until he resigned in 1932.

▲

A. G. Witting formerly chief engineer of the Gary Steel works has been appointed assistant to general superintendent of the Gary Steel works of the Carnegie-Illinois Steel Corporation.

Mr. Witting is a graduate of the Royal Technical Institute of Stockholm, Sweden, where he specialized in metallurgy and engineering. In January 1899, he came to the Carnegie Steel plant at Homestead, Pennsylvania, remaining there until May, 1900, when he was transferred to the Duquesne plant of the same company.

From 1901 to 1905 Mr. Witting was connected with the Wellman-Seaver-Morgan Company of Cleveland. In June 1905 he came to Chicago where he secured employment at the South works of the then Illinois Steel Company, a United States Steel Corporation subsidiary, as a draftsman. In 1911 he was transferred to the Gary works of the same company. He was promoted to the position of chief draftsman in 1918 and continued in this position until July, 1929, when he was appointed acting chief engineer for the Illinois Steel Company. In 1933 Mr. Witting became chief engineer for the company. In October, 1935, when the Illinois Steel Company became a part of the Carnegie-Illinois Steel Corporation, he was appointed chief engineer of Gary works.

(Turn to page 52)

Sun-Maid Raisin Growers ABOLISH COSTLY SHUTDOWNS on raisin conveyors by changing to . . .

FUSES MADE TO *protect*

So Says: Fresno Plant Electrician A. R. Cornelius

He continues: "We have seven conveyors that lift raisins from the receiving platforms to the fifth floor.

"Each is powered by a 7½ hp. 440 volt motor connected to a 30 ampere switch. Motor starting currents and temporary overloading of conveyors formerly caused almost daily fuse failures.

"Each failure was an expensive proposition as it stopped the steady flow of raisins to the treating and packing lines.

"In the Fall of 1934 we changed to BUSS super-lag fuses—to date but one of them has blown—and it blew to protect a motor that had run dry."

IF UNNECESSARY SHUTDOWNS *are Stealing Your Money* WHY NOT FIND OUT HOW . . .

BUSS

··NOT TO BLOW

...you too, can PREVENT THE RECURRING SHUTDOWNS caused by NEEDLESS BLOWS!

If you are interested in profits or production—BUSS fuses have what it takes to win your friendship.

They are designed to do only one thing—to PROTECT THE USER'S POCKETBOOK.

THEY DO THIS IN TWO WAYS:

1. By safeguarding equipment, plant and persons against electrical hazards—and

2. By preventing wasteful interruptions of operating schedules—due to needless blows.

In other words, they are made to protect—not to blow. To be sure—there are definite reasons . . .

WHY BUSS FUSES DON'T BLOW NEEDLESSLY

10 FEATURES in the design of the FUSE-CASE help make it possible . . . . *and* *The* **SUPER-LAG** development in the FUSE-LINK completes the job.

Super-lag FUSES

GET THE FACTS *ABOUT...*

- Fuse-case design and what it means in abolishing needless blowing of fuses.
- Time-lag, a key to shutdown prevention.
- The Super-Lag development and how it increases safety on short-circuit blows. . . . and many other interesting and valuable facts about fuses and their use.
- All set forth in easy-to-grasp style in the new BUSS book on "Fuses made to protect—not to blow."
- Your name and address will bring your copy by return mail.

BUSSMANN MFG. CO.
University at Jefferson • St. Louis, Mo.
Divison of McGraw Electric Co.

BUSS super-lag fuses are available thru Electrical Wholesalers

(Continued from page 49)

S. M. Jenks, formerly chief engineer of the Carnegie-Illinois Steel Corporation's construction engineering department in Pittsburgh, Pa., has been appointed to succeed Mr. Witting.

Mr. Jenks is a graduate of Cornell University, class of 1923, Degree of Mechanical Engineering. After a short period of service with the Jones & Laughlin Steel Company, he joined the engineering department of the American Sheet & Tin Plate Company at Pittsburgh, transferring to the Gary Sheet and Tin Plate mills as fuel engineer in 1929. Four years later he returned to Pittsburgh as power engineer for the same company, and in 1935 he was appointed assistant chief engineer. In September 1936, when the construction engineering division of Carnegie-Illinois was established at Pittsburgh, he was made chief engineer. This construction engineering division now has been placed under the jurisdiction of the company's chief engineer in the Pittsburgh District, and will confine its activities to that district.

▲

H. G. McIlvried as announced, by the Carnegie-Illinois Steel Corp., will become assistant to the manager of operations, Pittsburgh District.

H. G. McILVRIED

Mr. McIlvried will have supervision over the sheet and tin developments in the Pittsburgh District.

Mr. McIlvried's long service record with subsidiaries of the United States Steel Corporation began in the Braddock Works of the American Steel and Wire Company where he was a machinist. He went to the Rankin Works as a draftsman from Braddock and later returned to the Edgar Thomson Works at Braddock in a similar capacity. He was a construction engineer of the National Tube Company before coming to the American Sheet and Tin Plate Company in 1907.

Later he became chief engineer and assistant to the Vice President in charge of operations of this company. He was made assistant manager of operations, Chicago District, at the time of the merger creating the Carnegie-Illinois Steel Corporation.

Robert J. Tully, assistant general superintendent of the Clairton steel works and coke by-products plant, Carnegie-Illinois Steel Corp., has been appointed assistant general superintendent for the Youngstown, Ohio, district in charge of industrial relations. He will have charge of employment, safety and welfare at the MacDonald, Upper and Lower Ohio Mills where L. N. MacDonald is general superintendent, Mr. Tulley has been continuously employed by subsidiaries of United States Steel Corp. since 1895, when he became machinist apprentice of the American Steel & Wire Co. plant at New Castle, Pa. He became a job foreman of the Carnegie Steel Co. at New Castle in 1906 and later assistant master mechanic and master mechanic for a number of years at the same plant. From 1926 to 1932 he was general superintendent. He was master mechanic of the Clairton works in 1932 and after six months in that capacity became assistant general superintendent.

▲

T. D. Montgomery has been appointed manager of foreign sales by Cutler-Hammer, Inc. Mr. Montgomery has had wide experience in the application of Cutler-Hammer products, general company policies and methods of distribution. He brings to the foreign

T. D. MONTGOMERY

sales division a great appreciation of the need for closer contact and service to the many Cutler-Hammer customers in foreign countries.

▲

The Clark Controller Company announce the following changes in its personnel:

O. L. Holcombe, formerly Philadelphia District Office Manager, will again assume charge succeeding Mr. E. A. Hurme, who has resigned.

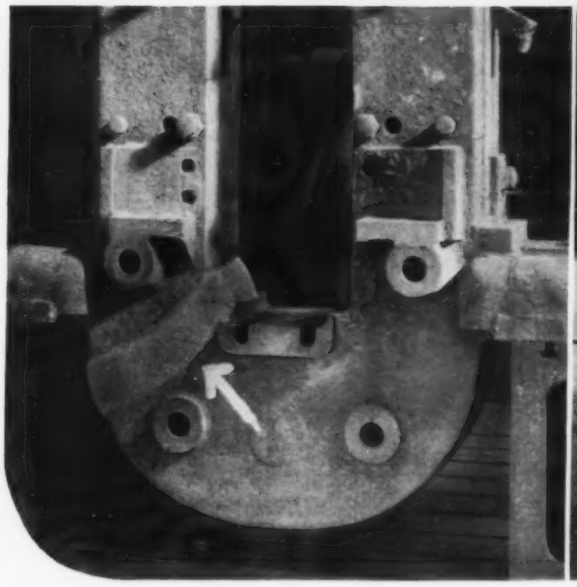
Robert H. Hoge will be located in the New York Office.

W. R. Uffelman will be located in the Detroit Office.

(Turn to page 56)

ADVERTISING PAGES REMOVED

HERE'S SALVAGE!
. . . with a capital "S"



Thermit Welding has been responsible for tremendous savings to the iron and steel industry. Broken rolls, pinions, housings, manipulator racks and heavy machine frames are salvaged and repaired the Thermit way at a fraction of replacement cost. Further economies are effected by avoiding the long delays and costly shut-downs which almost invariably result when new parts must be cast or forged. Actual savings on individual jobs frequently run to several thousand dollars.

There is every indication that even better times are ahead for the industry. It will pay you to prepare for them now by organizing a Thermit Welding Department. Our engineers, backed by many years of steel mill experience, will be glad to help with this work; to check over your scrapped equipment and report on parts that can be repaired profitably; to keep you posted on new developments in the application of Thermit.

Write today for a copy of the booklet: "Thermit Welding—Industry's Master Maintenance Tool", or, better still, ask to have our nearest representative call and give you the whole story in person.

THERMIT WELDING

METAL & THERMIT CORPORATION, 120 BROADWAY, NEW YORK, N.Y.
ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

(Continued from page 52)

J. W. Hammond will be located in the Pittsburgh Office.

S. J. Nogosek will be transferred from New York Office to the headquarters Sales Engineering Department, Cleveland, Ohio.

▲

Manufacturers Representative — Experienced engineer would be interested in representing in the Pittsburgh district a manufacturer of rolling mill and steel works equipment or some specialty allied with this line. Write AAN, 1010 Empire Building, Pittsburgh, Pa.

▲

Wanted—Steel Mill Designer, Strip Mill or General Design. Electrical Engineer Designer, Steel Mill. Permanent Positions. Salaries $250.00—$300.00. Write giving full details. "AA 2", 1010 Empire Building, Pittsburgh, Pa.

▲

Died

Harry E. Sheldon, for 35 years president of the Allegheny Steel Co., died after an illness of several months. He was 75 years old.

HARRY E. SHELDON

Born at Freeport, Pa., Mr. Sheldon began his career in the steel industry as a machine shop apprentice at $2 a week. Five years later he went to Leechburg as a laborer in the sheet mill of Kirkpatrick & Co. Working his way through the various trades he finally became general manager of the plant.

In 1900 Mr. Sheldon with Captain Alfred Hicks organized the Allegheny Steel Co. The company attained national prominence as a producer of "stainless steel." Last fall residents of the Upper Allegheny Valley region honored Mr. Sheldon at a huge reception honoring him for his contributions to workers and various charitable organizations.

John Matthewson, 67, general superintendent of the Alliance Machine Company and a prominent figure in the steel industry, died at his home in Alliance last month.

He was born in Belfast, Ireland, and came to Alliance from Massachusetts in 1905 to accept employment with the Alliance Machine Company. He became an erector for the company and in 1908 took charge of the Chicago office. He returned to Alliance in 1915 to assume the superintendency of the company, a post he held at the time of his death. In 1917 he erected machinery for the company in England and France and was in Europe when America entered the World War. Mr. Matthewson was one of the oldest and most prominent associate members of our society.

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Henry Giles, 46, general superintendent of the Carnegie-Illinois Steel Corporation's Wood works in McKeesport, died recently.

A graduate of Rensselaer Polytechnic Institute, class of 1911, Mr. Giles had been employed since 1917 by the American Sheet & Tin Plate Company, which was recently absorbed into the Carnegie-Illinois Corporation. He worked as construction engineer in Gary, Indiana, resident engineer in Elwood, Indiana, and assistant manager of the National works in Monessen. He was transferred in 1933 to

JOHN MATTHEWSON

HENRY GILES

McKeesport as assistant manager of the Wood works and made superintendent the following year.

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Harry Morrison, who recently retired as auditor for the Carnegie-Illinois Steel Corp., Chicago, died on January 24.

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William D. Bennett, superintendent of the Carnegie-Illinois Steel Corp., rail mill at South Chicago, Ill., died January 27, aged 51 years. He had been associated with the United States Steel Corp. for about 30 years.